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Einsatz sozialer Roboter in einem datenschutzsensiblen Kontext

Eine Fallstudie mit einem Open-Source Tagebuch Assistenten

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Employing Social Robots in a Privacy Sensitive Context

A case study on an Open-Source Diary Assistant

DIPLOMA THESIS

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Ana-Catalina Sabie

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Kurzfassung

Soziale Roboter werden schon seit langem eingesetzt, aber es gibt immer noch Hürden, wenn es darum geht, solchen Geräten zu vertrauen und intime Daten mit ihnen zu teilen. Dies ist zum Teil auf allgemeine Datenschutzbedenken zurückzuführen, kann aber auch von den Interaktionen mit dem Roboter und den Erwartungen der Menschen an ihn abhängen. Die Forschung zeigt, dass diese Faktoren einen großen Einfluss auf die Art und Weise haben, wie ein Roboter in verschiedenen Kontexten genutzt wird bzw. mit ihm interagiert. In dieser Diplomarbeit wurde die Frage nach dem Vertrauen der Menschen in persönliche soziale Roboter anhand eines roboterbasierten Tagebuchs in einem häuslichen Kontext untersucht. Der stationäre QBo-Roboter war mit einer Sprache-zu-Text-API ausgestattet, die Eingaben in englischer Sprache erkannte und sie lokal in Textdateien mit dem Datum des jeweiligen Tages speicherte. Die erste Version der Tagebuchimplementierung auf dem Roboter wurde von einem Interaktionsexperten evaluiert und entsprechend seinen Empfehlungen überarbeitet. Dazu gehörte, dass mehrere Interaktionsmethoden mit dem Roboter angeboten wurden, dass er abwechselnd Fragen stellte und dass die Benutzer*innen darüber informiert wurden, wie ihre Daten gespeichert und analysiert wurden. Danach wurden vier Personen mit unterschiedlichem Hintergrund gebeten, vier bis fünf Tage lang täglich Einträge vorzunehmen. Alle Teilnehmer*innen mussten vor und nach der Studie eine Reihe von Interviews und den Godspeed-Fragebogen (ein standardisierter Fragebogen zur Benutzererfahrung in der Mensch-Roboter-Interaktion) ausfüllen. Die Tagebucheinträge wurden in Verbindung mit den Selbstauskünften aus den Interviews und Fragebögen ausgewertet.

Die Auswertung ergab, dass die Teilnehmer*innen den Roboter in ihren persönlichen Kontext einbezogen und keine Bedenken hinsichtlich der Privatsphäre hatten, da sie mit der Forscherin vertraut waren und wussten, wie ihre Daten gespeichert wurden. Sie zeigten auch eine unterschiedlich starke emotionale Bindung an den Roboter, die sich in der Art und Weise widerspiegelte, wie sie mit ihm und über ihn sprachen, sowie in der Art und Weise, wie sie ihn benutzten, wobei sie das Verhalten des Roboters manchmal an ihre eigenen Vorlieben anpassten. Die Teilnehmer*innen hätten einen gesprächsfähigeren Roboter bevorzugt, was die Tatsache unterstreicht, dass sie offen für die Idee waren, mehr mit dem Roboter zu sprechen, möglicherweise auch über persönliche Themen. Ratschläge des Roboters wären nicht angenommen worden, wenn es sich um persönliche Angelegenheiten gehandelt hätte, aber die Teilnehmer*innen hätten stattdessen faktenbasierte Empfehlungen in Betracht gezogen, insbesondere wenn

der Roboter ihnen mitgeteilt hätte, wie er zu diesen Schlussfolgerungen gekommen ist. Diese Studie zeigt, dass es wichtiger ist, auf die qualitative Interaktion zu achten als auf die Gestaltung einer Schnittstelle zum Schutz der Privatsphäre, auch wenn die Sorge vor böswilligen Dritten der entscheidende Faktor bei der Erwägung des Einsatzes eines sozialen Roboters im persönlichen Bereich wäre. Darüber hinaus zeigen die Erwartungen und Bedürfnisse der Teilnehmer*innen hinsichtlich verbesserter Gesprächsfähigkeiten, dass die Integration von sozialen Robotern als Gesprächspartner in privaten Kontexten Potenzial haben könnte.

Abstract

Social robots have been employed for a long time, but there are still hurdles when it comes to trusting such devices and sharing intimate data with them. This is partly due to general privacy concerns, but can also depend on interactions with the robot and what people expect of it. Research shows that these factors heavily influence the way a robot will be used/interacted with in different contexts. In this diploma thesis, the question of people's trust in personal social robots was investigated using a robot-based diary in a domestic context. The stationary QBo robot was equipped with a speech-to-text API that recognized inputs in English and stored them locally in text files with that day's date. The first version of the diary implementation on the robot was reviewed by an interaction expert and changes were made according to his recommendations. These included offering multiple interaction methods with the robot, receiving alternating questions from the device and telling users how their data is being stored and analysed. Second, four people from different backgrounds were assigned to make daily entries for four to five days. Each participant was required to complete a series of interviews and the Godspeed questionnaire (a standardized user experience questionnaire for Human-Robot Interaction) before and after the study. The the diary entries were interpreted in conjunction with the self-reporting data from the interviews and questionnaires.

The user evaluation revealed that participants included the robot in their personal context and did not have any concerns over privacy only due to the fact that they were familiar with the researcher and were aware of how their data was stored. They also exhibited different levels of emotional attachments to the robot, reflected in the ways they talked to and about it, as well as different ways of using it, sometimes adapting the robot's behaviour to their own preferences. The participants would have preferred a more conversationally capable robot, underlining the fact that they were open to the idea of talking to the device more, possibly also about personal matters. Advice from the robot would not have been taken if it was on personal matters, but the participants would have taken fact-based recommendations into consideration instead, especially if the robot had told them how it reached those conclusions. This study shows that it is more important to pay attention to a qualitative interaction than to the design of an interface for privacy, even if concerns about malicious third parties would be the decisive factor when considering using a social robot in the personal space. Furthermore, the expectations and needs of the participants regarding enhanced conversational skills show

that the integration of social robots as conversation partners into private contexts might have potential.

Contents

CHAPTER 1

Introduction

The study of human-robot interaction (HRI) has gained popularity in recent years, and a variety of robots are now being included into our daily lives. Social robots are the ones that come closest to emotionally supporting people. This kind of robot is an autonomous agent that engages in social interactions with people and expresses intention by using behavior that people can understand. (Breazeal and Scassellati, 1999). Social robots can be employed in multiple fields, but are primarily being used for helping people with emotional needs or learning disabilities (Belpaeme et al., 2018; Scoglio et al., 2019). Particularly for such reasons, it is important to investigate the effects of such robots or our relationships to them on our emotional well-being. Especially feelings of trust can persuade someone to engage not only with other people but also with a social robot (Naneva et al., 2020).

However, there are multiple factors that can affect a person's trust towards a robot, such as its levels of anthropomorphism, its physical posture or verbal cues (Natarajan and Gombolay, 2020; Yang et al., 2021). The anthropomorphism of robots is an effect that is much discussed in the field of social robotics. The appearance of robots also leads to the automatic association with particular capabilities or a particular environment (Goetz et al., 2003); for example a robot with big arms might be associated with having capabilities fit for an industrial complex. Apart from appearance, voice recognition can also lead to people giving robots a specific gender and therefore behaving differently towards them (Crowell et al., 2009). Moreover, as technology advances, multiple factors can arise that also play a part in the way a robot is perceived by its user. For example, the level of conversational abilities are already improving through novel programs like ChatGPT, a chatbot that provides realistically formulated responses. This, in turn, can increase collective expectations regarding the abilities of social robots (Rathore, 2023).

Indeed, it has been shown that people tend to have high expectations of a social robot in the beginning, but that the level of uncertainty after the interaction decreased while their social presence increased (Edwards et al., 2019). The cited work presents two

participant groups, one of which is asked certain questions by a human and the other by a humanoid social robot. The results show that a high level of anthropomorphism positively influenced feelings of uncertainty in participants and ultimately lead to similar behavior as those who interacted with a human instead.

This prompts the question of what information lay people would want to share with a device if it was placed in an intimate setting. This thesis aims at identifying the hurdles that social robot developers and designers need to overcome in order to gain the person's trust regarding private information. Moreover, it aims at targeting what possible additional elements should to be taken into account when designing a social robot for privacy-sensitive contexts.

The aforementioned trust issues will be looked at more in-depth, as there is little research regarding when people are reluctant to share more personal information with a robot. Since this is an experimental environment, it is possible that individuals will overcome some of their hesitation in order to engage with and employ the robot in their homes as a journaling device/companion. This study examines and narrows the gap between the design of social robots and the level of lay people's trust. The integration of a personal diary assistant into a stationary humanoid robot intends to anticipate potential increases in the adoption of social robots in domestic settings. This study may be used as inspiration to look into ways how to reduce people's mistrust of social robots and increase the likelihood that robots will be trusted with sensitive data.

1.1 Research Questions

Research Question 1: "What are people's expectations or concerns in the design of social robots in private contexts?"

Assumption 1: While the expectations of the robot might depend on the specific device used in the study, it would be interesting to see which additional functionalities and properties the participants wish to have after using a social robot as a diary device/companion. It can also be expected that they have set a high bar for the robot's chat functionality, as personal assistants are widely available and have a large compendium of words that they can understand.

It is plausible that the participants' concerns regarding trust are also tied to privacy-related issues, for example if the robot is using a Google-owned voice assistant program. While this is speculative and subjective to each company, participants might have certain preconceptions about specific companies and thus be weary about using the robot as much for entering personal data.

Another hypothesis for this research question is that participants will not take the robot very seriously or see it as relatable and trustworthy, due to it having few humanoid features. While high anthropomorphism leads to an increased level of trust (Schaefer et al., 2016), the QBo robot, used for prototyping in this thesis, has few humanoid features and no clearly assigned gender. This might make it difficult for participants to

form an emotional connection with it or trust it, as it would resemble a more common device too much rather than a capable social robot.

Research Question 2: "To what degree do people employ a social robot in their personal space?"

Assumption 2: Keeping in mind that there are studies that suggest that voice recognition and humanoid features increase trust (Sanders et al., 2014; Schaefer et al., 2016), it is possible that participants will be open to frequent interactions with the robot, where they trust it with more information each time. This question will be answered by implementing a use case with the QBo robot and evaluating it through an expert and a user study. This, in turn, could signify whether there are multiple levels of trust being perceived by the participants or whether they have any privacy concerns at all, depending on the way they interact with the robot.

It is expected that, while the entries that participants create with the robot will not be very intimate, given the research setting, they will encompass more than passive information. This information will be analyzed and asked about during the user reviews, however, it could allude to the possibility that people might entrust social robots with more personal information in their home. Additionally, since this is an experimental setting, people might overcome some of their initial reluctance towards robots for the purpose of the study. This might hinder the identification of precise elements that influence participants' trust towards the robot. Nevertheless, it is expected that at least some suggestions or possible new findings will be discovered, as there is little research where a social robot has been employed in the role of a personal diary.

In answering this research question, further necessary features and ways of engagement with a social robot in a domestic setting will be uncovered. As it is relevant whether the participants practice journaling in the first place, their general stance on using a social robot as a desktop personal assistant will be assessed. It would also certainly make a difference whether the robot has a voice assistant and can complete additional tasks to being a diary application. This would give a more coherent picture regarding the possibilities of equipping social robot with a diary application in the future.

1.2 Proposed approach

In order to answer the research questions posed above, the social robot QBo will be equipped with a diary application. This environment will allow people to create spoken journal entries and store them locally on the robot. QBo can also react to the keywords "bad day" or "good day" with either "I am sorry you had a bad day! What happened?" or "I am glad to hear you had a good day! What happened?". These reactions are meant to prompt the user to talk to the robot more in depth about their day. The device also has two possible interaction opportunities; the first one is the "listening mode", in which a person can talk without receiving interruptions from the robot. However, in the "chat mode" the device asks the user about what they ate that day, how work was or if there

was anything else that they want to talk about. For the first two questions, specific keywords are stored manually. This hard-coded approach is meant to simulate contextual reactivity from the robot and help people engage more with it.

Multiple qualitative and quantitative evaluation methods will be conducted. The precise approach can also be found in Fig. 1.1 Firstly, the initial implementation is discussed with an interaction expert. This interview intends to uncover possible errors and further recommendations for the improvement of the robot. The expert review also provides an opportunity to discuss the approach with a knowledgeable third party who can suggest alternative methods of conducting the next steps of the evaluation. Furthermore, they can make predictions on the outcome of the study and propose certain changes.

A second implementation phase following the expert review will take place, where their recommendations are taken into account and the course of action for the rest of the study is improved. This includes additional changes to the diary application as well as modifications to the following methodological approaches, in order to adapt the received advice best to the study and the robot at hand.

Afterwards, a user study will be conducted, which also includes a number of different evaluation methods. The participants will have to give an interview before and after the study, as well as complete the Godspeed questionnaire (a standardized scale to measure human perception of social robots Bartneck et al., 2009) both times. The participants' diary entries and interview answers will be evaluated qualitatively and similarities and differences in themes will be identified and analysed. The content of their entries is less relevant than how qualitatively expressive they are. For instance, signs regarding the participants' enjoyment of the interaction, opinion of the robot and other emotional behaviours will be looked for. Analysing the participants' Godspeed questionnaire results is a further quantitative method to better visualise their opinions of the QBo robot before and after the study and to single out possible further influential factors on the users' experience.

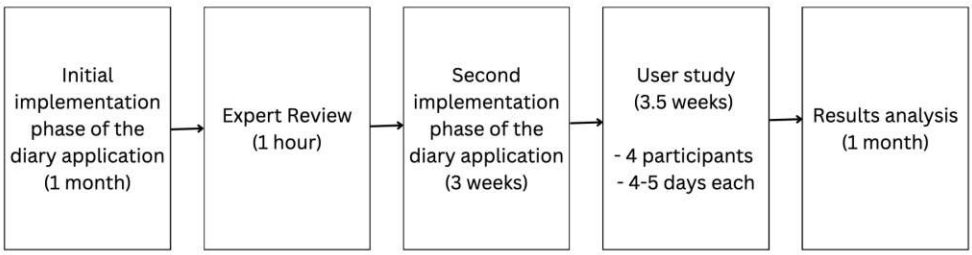

Figure 1.1: Methodological approach of the study

1.3 Structure of the work

This work consists of seven chapters in total. Firstly, this chapter is an introduction to the topic of the thesis and presents the aim and proposed research questions. Next,

supporting literature that leads to the assumptions developed during this work is shown, which also provides a necessary knowledge about the state of the art of HRI with regards to trust. This chapter is also relevant to present the research and evaluation methods in more detail. The third chapter presents the technical course of action of the work, the implemented classes of the robot and other specialized information relevant for the programming of the diary application and of the robot itself. The recommendations resulting from the expert review are then laid out.

Afterwards, the results of the participants' user study are presented in detail, in the form of participant profiles. Information regarding each participant is provided separately, in order to present each of their experiences in more detail and give a better impression of their personalities and opinions. Similarities and differences across the participants' profiles are then discussed in the following chapter, underlining possible outlying opinions or actions. These findings are then also compared to existing literature and argued for where possible. Finally, the work is concluded by stating the limitations present in this work and their causes, as well as possible improvements and recommendations for future works.

CHAPTER 2

Related Works

2.1 Social Robots

Nowadays, robots may take over a variety of takes and roles for humans, from automating chores (Forlizzi and DiSalvo, 2006) to emotionally assisting elderly people (Kang et al., 2020). They can even help children with learning languages or overcoming obstacles by observing social signs (Dawe et al., 2019; Kennedy et al., 2016; G. Kim et al., 2021). Although using a robot in one's everyday activities might have numerous advantages, most people find it difficult to adopt them into their life. For example, there might be resistance regarding language barriers, lack of knowledge, a too high perceived intelligence or other impediments (**\cite {DeGraaf2017WhyStudy}**). Another instance might be switching the word "robots" to "appliance" appears to boost likeability and acceptability, increasing marketability to a wider audience (J. S. Kim et al., 2020). Nonetheless, people in general have a favorable opinion of social robots, especially if the interaction takes place face to face and not indirect (Naneva et al., 2020).

However, humans may not be overly hopeful about integrating robots into our society. While dealing with an android, people frequently take care to distinguish between humans and machines, highlighting the possibility that individuals would find it difficult to emotionally relate to robots (Angeli and Brahnam, 2008). Furthermore, ascribing a role to robots is a subconscious process, that heavily depends on the context and perception of users of certain jobs (Joosse et al., 2013). For example, Joosse et. al have observed that in certain contexts, the theories of similarity attraction and complementary attraction do not always hold and that instead of employing robots for tasks based on their personality, they should be rather chosen depending on the perceived stereotypes regarding that job. This research shows that the way robots are perceived is more complex than factors influencing likability on a surface level, which can ultimately influence our expectations on how robots should be employed in the future. It also underlines how

different contexts of employment can affect preferences regarding robot personalities and ultimately determine how they will be used.

People's interactions with robots as portrayed in the media has also been discussed, as well as their influence on people's common expectations of social robots in reality (Horstmann et al., 2018; Weiss et al., 2011). These two works mention that such high expectations generally come from people who have no experience with robots. Moreover, robots in movies are not always shown as very socially-apt, but instead have very advanced cognitive capabilities, raising the bar for real devices who do not exhibit human-like or such exceptional features (Kriz et al., 2010). Horstmann et. al furthermore underline also the fact that negatively perceived fictional robots also lead to increased concerns regarding robots becoming a possible threat to people Horstmann et al., 2018.

2.2 Requirements for a diary environment

There is limited research in the area of using a robot as a diary device. One piece by Duan et. al shows however, that there are benefits in talking to a social robot for therapeutic reasons, especially in situations where the user had previously seen something particularly shocking to them (Duan et al., 2021). However, participants in Axelsson et. al's research project have shown mixed attitudes towards working with a robotic well-being coach (Axelsson et al., 2021). This could indicate that people would accept advice from a robot in very particular situations or that they are apprehensive when a robot plays the role of an authoritative advice figure. Because resources are constrained, we can only assume requirements that can be proposed for the development of a robotic journal.

As a general requirement for diaries, Kenyon proposes some guidelines, that have been proven to be efficient for paper diaries: a diary entry should last for 20 minutes per day, the diary should be operated intuitively and have a shallow learning curve (Kenyon, 2006). Additionally, it should ask participants for the information that needs to be completed at every stage of the diary. While some of these guidelines might be too constraining in the discussion with a social robot, they provide an appropriate basis of a frame for a robotic diary.

According to the principle of common ground, people subconsciously build mental representations of robots based on their social cues (Kiesler, 2005). People assess how much they have in common with the robot and, consequently, how much effort they will need to put into the encounter using this mental model. Their emotions and the amount of time they spend speaking with the robot are then influenced by this instinctual process. The theory of common ground implies that people's moods and emotions are influenced by how close they feel to the robot.

This is especially relevant to a diary setting, as people might not always be in the mood for talking at length about their day, regardless of the quality of their interaction or their trust towards the journaling medium.

2.3 Trust factors

As trust is a major subject in this work, potential design aspects that promote trust and privacy in human-robot interaction will be looked at.

Researchers have found a correlation between how humans see robots and how much trust they receive. They found that people are more willing to cooperate with robots that resemble humans and subsequently also trust them more (Schaefer et al., 2016). In a related study, it was shown that participants were more inclined to trust a robot to make decisions when those choices had a low to medium "impact of consequences" (Rossi et al., 2020). While the robot in this study does not make any decisions for the participants, keeping in mind that people are apprehensive of programmed moral judgement might help in understanding the participants' level of trust in the robot when it comes to conversation about their intimate thoughts.

Robots' moral judgments in fields like law and health were questioned even when they produced favorable outcomes (Bigman and Gray, 2018), suggesting that there is little confidence in them or that they would not like a robot telling them unfortunate news and create doubt. Elevating the robots' perceived experience and skill or giving them an advisory position made individuals more receptive to their advice and inclined to believe them. Contrarily, however, if the robot explains why a lapse of judgement might occur when it is making a recommendation, it also increases the user's level of trust towards it in specific situations (Natarajan and Gombolay, 2020).

As there are several ways to define trust in relation to social robots (Kok and Soh, 2020), there are various ways to actually acquire it. The idea that one's sense of privacy improves their sense of trust is generally held and has recently attracted attention in the legal community (Richards and Hartzog, 2015). Therefore, we should also account for factors that allow users to overcome any privacy concerns they may have, in order to increase trust. One study by Vitale et. al (2018) explains how privacy concerns are influenced by how transparent a robotic interface is while collecting data, which in turn affects how users interact with the robot. The physical behavior of a robot also affects privacy concerns, as Yang et. al have discovered that these are reduced if the robot makes a visible effort to protect the user's privacy (Yang et al., 2021). Regarding the expectations people have about what role robots could play in the future in terms of privacy, Weiss et. al discovered an ambivalent stance: on one hand, people would rely on robots for carrying out dangerous tasks, reducing risk for humans. On the other hand, robots would still need supervision when carrying out these tasks, so humans can not get harmed in the process (Weiss et al., 2011).

That is why the users will be shown how the robot stores their entries and will also be instructed on how to find their entries. This ensures that they have full transparency over how the robot handles their data. Additionally, they are asked for consent regarding the usage of their data for the purposes of this study. No personal or identifiable details will be disclosed and they can opt out of the study at any time. They are not given

specific instructions regarding what information they should share with the robot and are encouraged to use it as they normally would a physical diary.

2.4 Design of HRI interfaces

Well-implemented interfaces in HRI is not only important for a positive user experience, but also contributes to a user's impression of social robotics and influences their future interactions with social robots (Van Greunen, 2019). Moreover, the option to personalise a robot's interface is even desired and can also strengthen the relationship between the user and the device (Lee et al., 2012). This is why it would be important to look into possibilities that could allow the robot to learn from the participants. Questions such as what line of work they are in or whether they had any siblings or significant others could potentially go a long way. However, it should be taken into consideration that robots should not ask overly intrusive questions, in order to turn the participants away from the idea of stealing private data.

Tonkin et. al investigated the design process in HRI, aiming to verify lean user experience (UX) guidelines in the development of a commercial robot placed in a an airport (Tonkin et al., 2018). The authors argue that an iterative design process, which requires constant user feedback, is best when incorporating HRI research into UX practices. While the used methodology was deemed best for the chosen field study, it would be interesting to test it against a robot that people would interact with more intimately, for example when journaling at home. An repeatedly improved upon interface has been often shown to lead to a positive user experience, as the relationship between users and social robots advances and changes constantly (Lindblom and Andreasson, 2016). This aids in the adjustment of interface design to new challenges, as Alenljung et. al discuss, and approaches unaddressed issues and gaps in the design for specific user groups (Alenljung et al., 2017).

The work of Axelsson et. al (Axelsson et al., 2021) concluded that people deemed interaction with a robot via voice or speech more important than other interaction modalities. Underlining the importance of the type of engagement with the robot, it would be important to utilize a non-intrusive interaction mode especially in intimate settings.

2.5 Methods

With respect to the methods and to their execution, the approach used in this thesis was chosen due to the arguments made by the aforementioned works.

2.5.1 Implementation

Firstly, an iterative implementation process is employed, as the need for this approach was underlined by the likes of Tonkin et. al. Tonkin et al., 2018. This can be seen due to the fact that two phases are taking place, reserved for writing and modifying the code of

the diary application and the robot's behaviour. The first phase is especially important to scope out matching software or voice assistants that could be used during the study as a conversational partner. During this phase the basic structure of the program is laid out and prepared for the expert's review, by inserting modular components and variables that can be altered later on.

The second phase looks at possible improvements that can be made following the expert review. While in this phase less scouting for solutions is done than in the first one, it is still important to look for solutions to carry out as many suggestions as possible or to integrate them into other phases of the study such as the interviews of the participants.

In order to understand what the participants feel about their interaction with the robot, evaluation methods that gather qualitative data are employed, such as interviews and written text. While there are other available methods that look at the users' engagement through physical cues (Anzalone et al., 2015), behavioural cues are followed throughout the interviews.

Weiss et. al propose a "think-aloud" approach in order to identify participants' emotions during a study better (Weiss et al., 2009). As the participants of this study would interact with the robot unobserved, this method cannot be employed. However, details on the participants' emotions toward the robot are looked for in their entries during the study. They are also asked how they felt about the robot after the study and further statements are inquired about during the interviews. Furthermore, the Godspeed questionnaire presented below can help identify emotions towards the robot from an HRI-relevant perspective. This is particularly relevant because participants can identify their opinions themselves better, as emotion is not always expressed through the same behaviour ("Emotions, Cognition, and Behavior - Google Books", n.d.).

2.5.2 Interviews

In order to ensure that the participants' opinions and experiences are understood and and their behaviour interpreted correctly, special attention is dedicated to the creation of the interview questions. For this purpose, several commonly used questionnaires were used as inspiration for different contexts of questions. The scales themselves were not adopted in this study, but rather the phraseology and topic of the question. This is due to the fact that some questionnaires have scoring systems that pertain rather to specific ethnic groups, for example depending on certain tendencies or preferences that arise in that area (MacDorman et al., 2009). In the cited paper for example, MacDorman et. al discuss whether the following questionnaire developed by Nomura et. al could be used in other countries than Japan, the originating country of the researchers. This is because Japan has a higher tendency to favour robots and the proposed scoring system could account for such preferences. Furthermore, translations into other languages have the risk of not being accurate and thus not measure on the intended, original scales (Auer et al., 2000).

The "Negative Attitudes towards Robots Scale" (NARS) developed by Nomura et. al is a free-form, scale-based questionnaire that particularly looks at people's anxieties towards robots (Nomura et al., 2006). The questionnaire includes areas investigating "Situations and interactions with robots", "Social influence of robots" and "Emotions in interaction with robots". It has also been shown to represent people's changes of attitude towards a robot well (Nomura et al., 2008), which is especially relevant for the user evaluation, as the interviews will be conducted before and after the participants' interaction period with the robot.

Additionally, the "Scale for Assessment of Attitudes Towards Social Robots" (ASOR-5) (Damholdt et al., 2016) was used, as it looks rather at the perceived abilities of the robot. More specifically, it takes into consideration "the ascription of mental capacities", of "socio-practical capacities" and of its "socio-moral status". Asking about these aspects is valuable to understand what role the participants attribute to the robot and can uncover whether a social robot could be more than a practical appliance, due to the proposed role. For example, making the difference between a stranger or a friend would mean a different level of trust and subsequently shared information with the device.

Lastly, the "Multi-dimensional Robot Attitude Scale" (MDRAS) was taken into consideration (Ninomiya et al., 2015). This scale-based questionnaire investigates a potential user's attitude towards a domestic robot across 12 different areas including the ones mentioned above and more, such as "familiarity", "interest", "utility" and "variety". Even though the purpose of this questionnaire focuses mainly on the needs of consumers and is more than five years old, it can still help outline potential basic requirements that people would expect or want from a robot, especially a social one employed in their own homes.

2.5.3 Godspeed questionnaire

The Godspeed questionnaire by Bartneck et. al is a Likert-based scale questionnaire that assesses the attitude of a person towards a specific robot (Bartneck et al., 2009). The investigated aspects of the robot in question are:

- *Anthropomorphism*, which investigates how much the robot resembles humans in terms of motion, naturalness and consciousness.
- *Animacy*, a similar attribute to the previous one. However this category refers to how life-like the robot is to the participants and whether it seems interactive or responsive.
- *Likeability*, asking the participants about how much they liked the robot, whether it seemed kind or friendly.
- *Perceived Intelligence*, where the questions refer to the perceived level of competency, responsibility and sensibility of the robot.

- *Perceived safety*, which rates how anxious or surprised participants were in the robot's vicinity.

In this study the questionnaire is meant to compensate for the limitations of a participant interview. Firstly, participants can complete the questionnaire on their own without feeling any pressure of being supervised or questioned by the researcher. The questionnaire can also sum up a participant's opinion better due to the Likert-scale point system, in case they communicated it wrongly during the interview. Moreover, this method ensures that participants are being asked about multiple matters regarding a robot, that might have been missed during the interviews. Even though few participants are being recruited for this study and there is a risk of not obtaining quantitatively expressive results, having the users contemplate about concrete opinions and attributing the robot a score can also help them differentiate between aspects that they liked or disliked about the robot in more detail.

CHAPTER 3

Methods

The study was divided into five phases: (1) Initial programming of the robot, (2) Expert review, (3) Iteration of robot programming, (4) Preparation of user study, (5) Conduct of user study. Firstly, after scoping out the state of the art in terms of the usage of technology as a journaling medium in chapter 2, the robot was programmed. This phase consisted of configuring the firmware of the QBo robot, searching for matching programs that could be used and finding a suitable speech-to-text recognition software.

An expert review was conducted to determine whether the setup could produce insightful results and to provide feedback on the program. During this session an expert focused on interaction architecture was asked to interact with the QBo. Following a short exchange, an interview was conducted that focused on possible improvements and expectations regarding the user study. The review received during the expert analysis as well as possible limitations given by the used software were taken into account when extending the robot's capabilities. The majority of the upgrade was modifying how people interacted with the robot and giving it additional chatting capabilities.

A plan was then developed to serve as an overview for the user study phase. Four participants from varied backgrounds were recruited and the the user research took place over the course of three weeks. Each participant was questioned about their overall perspectives on the interplay between social robotics and trust and their opinions and expectations of the QBo robot during a preliminary interview. After setting up the robot in their homes and receiving an informational sheet regarding how to operate it, the participants had to use the device to record daily entries for each instance, which was expected to take 4 to 5 days. After the engagement session, a follow-up interview was done to see if there had been any shifts in the participants' perspectives after interacting with the robot.

After both interviews the participants were also asked to complete the Godspeed questionnaire (Bartneck et al., 2009). This questionnaire uses semantic differential scales, on

which robots can be rated on a 5 point scale between bipolar adjectives, five for each dimension: anthropomorphism, animacy, likeability, perceived intelligence and perceived safety. Firstly, the questionnaire was asked to be completed after the first interview of the participants, after they were shown how to operate the robot and it was set up for their environments, according to its initial placement in their homes and their local wireless network. The second time the questionnaire needed to be filled out was after the user study had taken place and after the participants took part in the closing interview and the robot was taken away

This observational work employs both qualitative and quantitative research methods, aimed at gathering information on the participants' perspectives by analysing their diary entries and interview answers from a qualitative point of view. The interviews were designed to include questions on the participants' perceptions of robots, about their expectations for the use of social robots in the future in various circumstances and their opinions on trust factors between users and social robots. Their actions or expressions used during the interviews were also scrutinized more closely since they could unconsciously display certain behaviors that might point to other details. Moreover, the Godspeed questionnaire was adopted as a quantitative method to allow participants to pinpoint their opinions of the robot used during the study more closely.

3.1 Initial programming of the robot

The QBo robot comes preconfigured with two cameras and LED lights in its head and a Raspberry Pi 3 Model B in its body. A 32GB SD card was added as an addition. The operating system (OS) image for the robot was installed on the SD card. First, the third and most recent OS image was tested; however, due to several issues, it was quickly abandoned in favor of the second, ostensibly more reliable version, known as "OpenQBo V2.0."

During the initial setup it was noticed that the OpenQBo OS offers support for two voice assistance options: DialogFlow and Google Assistant. Both Google-created products give users the opportunity to chat with an artificial intelligence (AI) and connect to the internet. Dialogflow also has the possibility to alter conversational progress, for example by setting up certain keywords that trigger defined functions. On the other hand, the Google Assistant (GA) account can be connected to external accounts and linked to third party applications.

In the beginning of the implementation phase, it was assumed that working with the GA product would aid and hasten the development process. Thus, a new account was created and connected to the QBo's "interactive mode", which awakens the assistant automatically when the robot is started. However, while it is possible to download the GA software on any device that supports Python 2.7 or higher, Google does not identify it as an available device if it is not manufactured by a company that the company is in partnership with. This, in turn, means that third party applications using GA can not

recognize the device and thus not be able to connect with it when the assistant is given the command to do so.

A different approach was found by using the "IFTTT" automation application. Similar to Dialogflow, this app can create user-defined commands to the assistant. Additionally, it modifies the GA's connection to third party applications without needing to identify the device. This connection was also tested out with the note-taking app "Evernote", in the hopes that a user might be able to create an entry and send it to their personal journal on the Evernote app. Unfortunately, the application programming interface (API) that permitted IFTTT users to dictate text to the GA had been deprecated 2 months prior to the implementation phase. This meant that even though certain commands could be set up for the voice assistant, the online journal in the Evernote app could only receive messages with previously set sentences and not with ones dictated on the spot.

Following these attempts, the implementation was reconsidered. Multiple speech recognition packages offered by open sources were installed such as "Spchat" and "Real-Time Streaming Transcription" offered by AssemblyAI (Assembly AI, 2021; Warden, 2022). Nevertheless, all of these only support a Python version newer than 3.0. As the QBo software only supports Python 2.7, an upgrade to Python 3 caused the robot to malfunction and the OpenQbo OS had to be set up anew.

Last but not least, a novel approach was tried out, which uses the IBM speech-to-text API for the transcription of entries. The preexisting code was graciously offered by Oliver Jung from Salzburg Research and was afterwards altered according to the needs of the diary application use case. It initially also used the text-to-speech API offered by IBM as well. Unfortunately, as this requires the PyAudio module which resulted in an "ALSA" error when installed, the robot instead selects a downloaded audio file for each of the output responses. The audio files were acquired from the website www.ttsmp3.com, which renders written text into speech in the feminine voice 'Joanna'. The flowchart of the initial scenario can be found in Figure 3.1.

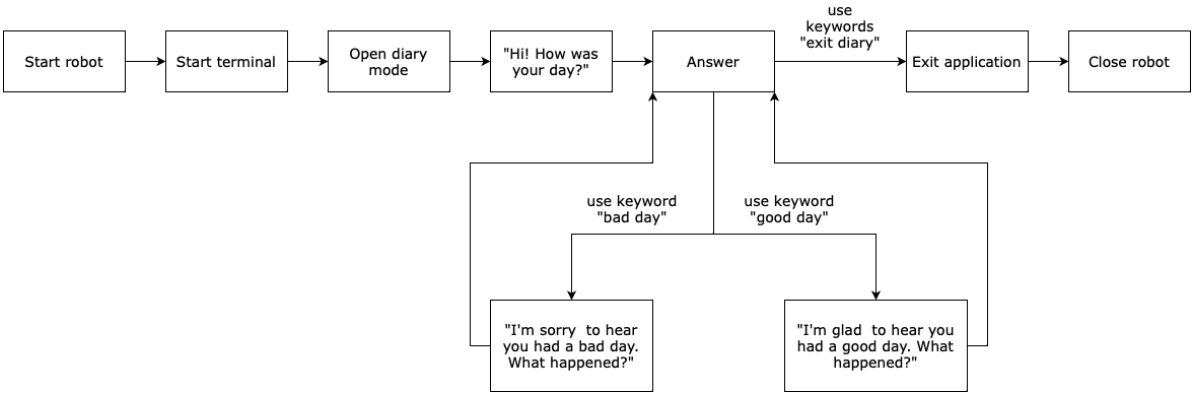

Figure 3.1: initial flowchart of the interaction with the robot

The original code was also modified to suit the behavior of the robot in terms of LED lights that were displayed. While playing audio, the QBo robot uses blue LED lights installed in the shape of a mouth in order to simulate the movement of the mouth. The robot's behavior during the act of speaking can be found in Fig. 3.2

Figure 3.2: QBo robot when talking to the user. The nose LED is turned off and the mouth LEDs are mimicking movement of the mouth when speaking.

The processing of a sentence takes the API 2 to 3 seconds of wait time until it is able to listen to and analyse the following input. This is an issue that lies with the API itself and cannot be resolved more quickly. For the purpose of showing the participants that it is listening to incoming input, QBo's nose LED lights up green after finishing the transcription of a sentence. This feature can be seen in Fig. 3.3

In order for the program to work, three classes that are implemented. These include some initial methods that define the way the robot is behaving during the interaction and how the speech-to-text recognition API works in the application.

Figure 3.3: QBo robot when listening to the user's input. The nose is green, indicating waiting and the mouth is in the default position.

- Main Program.py - This class determines the robot's main behaviour and follows the decision-tree in Fig. 3.1.
  - As the Python language does not need the user to define a starting method, the first steps are not written in the form of a proper method. The program starts by setting the robots' mouth shape to a blue heart and its nose to a green color. Afterwards, the file which will eventually contain the user's entry is created. It also checks if there already is a file with that day's date stored and opens it. This mechanism was put in place in case participants are interrupted during an entry or want to complete it at a later point in time. Without writing anything in the file yet, the program analyses any inputs it might detect and checks if they contain the keyword "diary", which triggers the diary application.
  - The robot stores the entry in a file using the *WriteToDiary()* method. Firstly, it sets the robot's nose color to green, letting the users know that it is listening

to them. Next it creates a variable "sentence" with the user's detected and processed audio. This sentence is passed to the *Various Functions.py* class and converted into a String object, which is subsequently entered into the diary.

- In the *ChooseAnswer(sentence)* method the program identifies when the user uses the "exit diary" trigger word or mentions having either a good or a bad day and prompts the robot to respond with its pre-programmed answers. The software evaluates the String object that represents the user-identified text input in the form of the "sentence" argument.
- The *ExitDiary()* method closes the text file in which the entry is saved, restores the color of the robot's LED lights for its mouth and nose and ends the program.

- *Processing Audio.py* - The audio input is passed to this class as a parameter in the *getAudioToText()* function in order to recognize the user's phrases. By using IBM's speech-to-text API it defines certain behavior (such as recognising a US English accent, identifying pauses, etc.) and returns the text as a String object to the same variable.

- *Various Functions.py* - For audio playback of the responses that the robot uses, this class chooses the right file based on the argument supplied to the *qboSpeak(sentence)* function. The "sentence" variable in this case refers to a String object that symbolizes the case for the robot's answer. It can have the values:
  - *firstResponse*, which describes when the user launches the application, to which the program answers with "Hello!"
  - *badDayResponse*, in case the user mentions the keywords "bad day", the program responding with "I am sorry to hear you had a bad day! What happened?"
  - *goodDayResponse*, the alternative to the prior value, activated by the keywords "good day" and answered with "I am glad to hear you had a good day! What happened?"
  - *leaveDiaryResponse*, when the user asks to exit the diary and the program says "Bye! Have a nice day!"

The code can be found in an internal folder, together with the audio response files for the initial scenario described above.

In order for users to operate the robot, they can either connect it physically to a monitor, mouse and keyboard or use a remote desktop software. The first method allows people to modify the robot locally, but presents some challenges such as removing the screws placed in the bodice of the robot and having to remove the cables in case the connected external devices needed to be reused in another environment, such as with the personal

computer. This set-up was used in the first instances with every participant, in order to connect the robot to the local wireless network. The second method entails using the VNC Viewer software by RealVNC, which allows the user to connect to a desktop remotely. For this use case, the program was downloaded on the robot as well as on the participants' computers (those who preferred this operating method). For the purposes of this study a new account was set up, which automatically saves the robot's IP address needed for remote connection. This account was then used by all participants, so that they did not have to re-enter the IP address on each connection, resulting in a less technically daunting operability.

3.2 Expert review

Professor Peter Purgathofer, a researcher at the human-computer interaction (HCI) institute who specializes in user-centered system design, interaction architecture, and the philosophy and practice of design, was the expert who was asked to perform an expert review of the first version of the use case. The robot firstly needed to be configured to a new network in order to undertake the expert review, as it requires a local internet connection. The interview took place in the institute's library while using the local WiFi network. In order to allow the expert to observe exactly what was happening throughout the interaction, the robot was disassembled and connected to external equipment (monitor, keyboard, and mouse) available in the library. The review lasted 45 minutes and was recorded with the professor's verbal consent. The details of the expert's recommendation can be found in chapter 4.

3.3 Programming following the expert review

The changes made following the expert review consisted mostly of additional code inserted into the *Main Program.py* class.

- The start behavior was expanded with instructions for the software to ask the user, as soon as the diary application is started and after saying "Hello", whether they are in the mood to chat or whether they want the robot to listen. The sort of interaction between the robot and the human is then determined by looking for the keyword "listen" in the user's input.
- The arrays *scenarioWork* and *scenarioFood* were introduced, which include terms that must be recognized in order for the program to determine whether the user has already discussed the corresponding scenarios.
- To keep track of whatever scenario has been discussed, the Boolean variables *talkedAboutWork* and *talkedAboutFood* were also created.
- *AskAboutScenario()* is the method where the program defines its behavior for the chatting mode. it starts by posing the scenario involving food and sets the

'talkedAboutFood' variable to the 'True'-value. The work-related scenario is then given, with the 'talkedAboutWork' variable modified. The third scenario, in which the user is questioned about any further information, comes last. If the user remains silent for more than ten seconds, the question from this scenario is asked again until the user closes the diary application.

- The *ChooseAnswer(sentence)* method was enhanced to check whether the aforementioned situations have previously been entered. It also checks the passage of the 10-second window during which the user may continue speaking or remain silent, triggering the next question from the program.

The *qboSpeak(sentence)* function in the *Various Functions.py* class was also extended to recognise the following variables:

- *askAboutMood*, which causes the robot to say "Do you want me to listen or are you in the mood to chat?" after "Hello"
- *ok*, Regardless of the answer to the aforementioned inquiry, the robot will say "ok" and either listen to the user's inputs or enter the conversational mode.
- *askAboutFood*, is the value for which the robot will ask "What did you eat today?", only if the user asked the robot to chat with them.
- *askAboutWork*, similarly to the last value, the robot will ask "How was work today?" after the user responds to the previous food-related question and stays silent more than 10 seconds.
- *askAboutAnythingElse* is the value for the third and final scenario of the chatting mode, in which the robot asks the user "Is there anything else you want to talk about?"

In order to enable the robot to wait for the passing of 10 seconds in the chatting mode, the *Processing Audio.py* class was altered with an exception called *WaitTimeoutError*, which causes the program to output "Nothing heard" in the terminal and start the listening process again, without disturbing the user or interrupting the program.

According to the programming of the robot by the manufacturer, if the speaker is not directly in front of it, the robot turns its head in their direction. This feature ensures that the person knows it is listening to them, additionally to the signal emitted from the green LED that represents the nose.

The new interaction flow with the robot can be found in Fig. 3.4.

3.4 Preparation of study set-up

For the purpose of providing suitable questions during the interviews, three widely used interaction evaluation questionnaires were consulted: the NARS (Nomura et al., 2006), ASOR-5 (Damholdt et al., 2016) and MDRAS (Ninomiya et al., 2015). The following are the contexts that were looked at in depth and integrated into the questionnaires used during the interviews.

- *NARS*
  - "situations and interactions": The participants were presented with hypothetical situations such as an alternative provenance of the software used for this study.
  - "social influence of robots": This category assessed their willingness to use social robots in general and their opinions on the place of social robots in society.
  - "emotions in interaction with robots": Participants were asked expressly whether they would like it if social robots displayed emotions and if so how they would like them to manifest it.
- *ASOR-5*
  - "moral relatedness": This context refers to the fact that some questions asked about the participants' willingness to accept advice from a social robot, in.
  - "intimate personal relatedness": Similarly to the last context, participants were asked about receiving intimate advice from a robot, for example regarding relationships.
- *MDRAS*
  - "familiarity": Questions from this context looked at what role the robot would play or played to the participants.
  - "efficacy": Participants were asked how the robot could have supported them better throughout the study, apart from additional conversational capabilities. Some possible additions could include new features or a different physical aspect.
  - "environmental fit": Apart from the aforementioned context, this one looks at how a participant would use the robot and how they would adapt it to their personal needs and their personal space.

The question catalogue can be found in the chapter "Interview questions"

One limitation that interviews can have is that participants might not be able to fully express their opinions. For this reason, the Godspeed questionnaire (Bartneck et al., 2009) was used to assess each participant's attitude towards the QBo robot on scales.

3.5 Conduct of the user study

In order to assure a wide variety of viewpoints, people from different backgrounds and with diverse affinities for technology were sought out. Each of their backgrounds can be found in the corresponding participant profiles found in chapter 4 "Results". Each participant had the robot in their house for four to five days during the study period, which lasted four weeks.

At the beginning of the study an interview was conducted, where participants were asked about their views on both robots and social robots in particular, possible experiences with them, the significance of trust and the future of social robots. When asked if they were familiar the term "social robots", the "Paro" robot was shown as an example in case they were not. The participants were afterwards shown the robot and questioned about their initial impressions on its physical appearance and subsequent expectations of it. After the interview, participants were shown how to operate the robot and helped to set it up in their homes. Written out instructions were also provided for them in case they were confused how to control the robot.

A qualitative analysis was performed to examine the participant's experiences from several angles. Firstly, their interviews were transcribed using the "Descript" application and inspected for defining thematic words. The discovered categories in the interview prior to the interaction period were: *"General impressions on robots", "Possible uses of social robots", "Influencing factors on trust towards robots", "Impressions on the QBo robot" and "Emotions in robots"* . In the second interview, the following themes were identified: *"Overall experience", "Trust" and "Outlook on the future of social robots"*. Additionally, the participants' diary entries were examined from the perspectives *"Content"* and *"Identified emotions"*. Chapter 5 provides more thorough descriptions of each group. Moreover, the participants behaviors throughout the interviews and entries were also analysed, in order to gather information that they unconsciously sent.

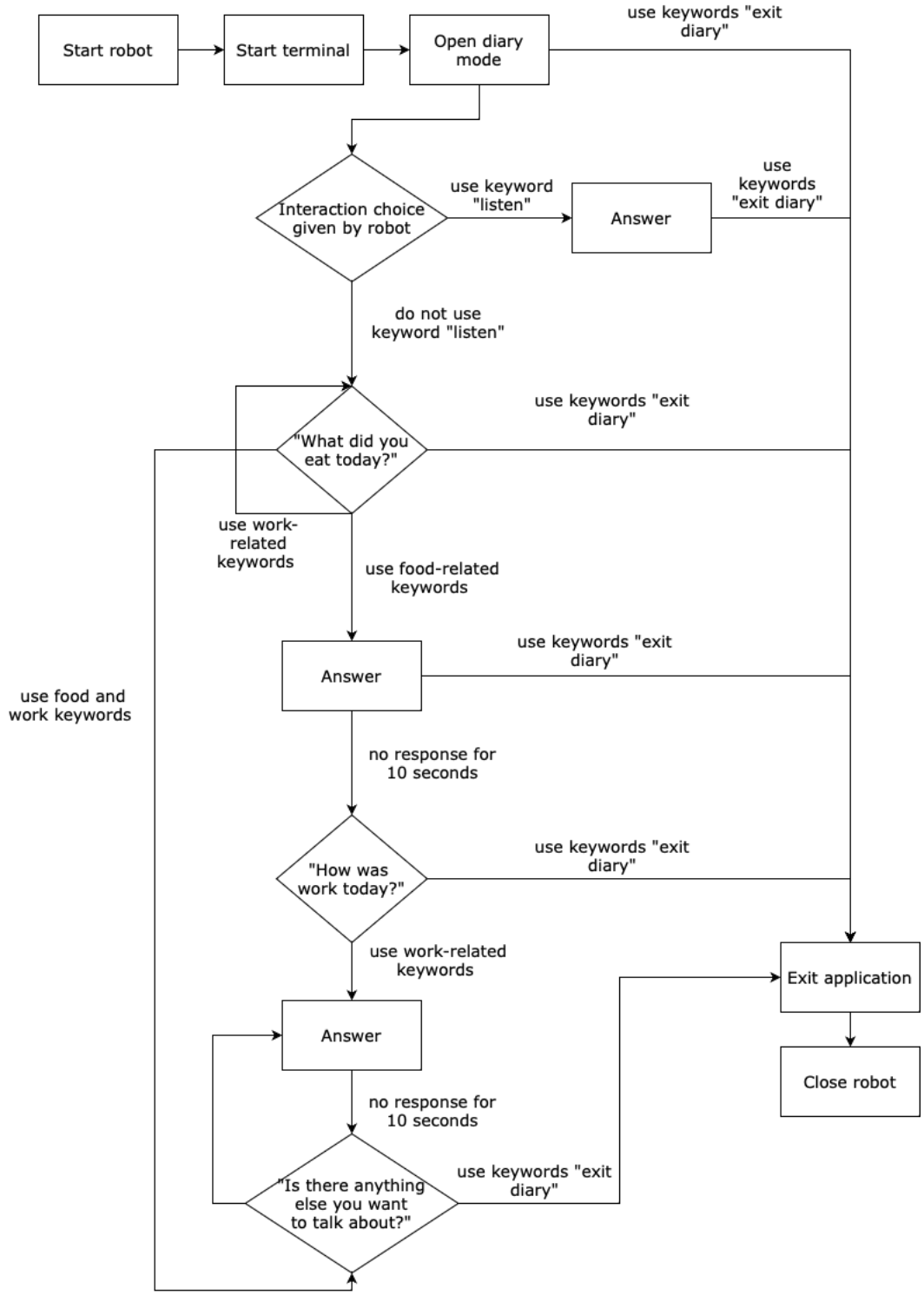

Figure 3.4: altered flowchart of the interaction with the robot, showcasing new behaviour options from the "Open diary" action and additional possibilities of interaction with the robot, each with hard-coded responses and new choices given by the software

CHAPTER 4

Results of the expert evaluation and subsequent modifications

This work looks at the relationship between people with social robots in the intimate use case of a personal diary. One particular focus is on the trust factors that sway a user's experience as well as possible other aspects that might influence how much information is being shared with the robot. In order to better understand this relationship, an expert review took place to receive feedback about the progress on the robot and further advice regarding modifications on the interaction between a user and the device.

Following the expert review described in more detail in the methodology chapter, the resulting advice was then taken into account for the subsequent development of the robot and preparation for the participant study. This chapter is thus sectioned into two parts: firstly the overall feedback from professor Purgathofer's review is presented, along with the foundation for the given advice. Secondly, the resulting changes to the implementation of the interaction with the robot and other implied modifications are described.

4.1 Feedback received

After setting up the robot and starting the diary environment, the expert was asked to start their interaction with the robot, but he did not know how to begin the exchange. The interviewer prompted them to talk about their day, leading to professor Purgathofer already giving their first remark: the robot should tell the user what to do or give them clues on the possibilities of interaction (1). The biggest concern of the expert was that the participants would also be confused when first starting the robot, even if they received a description of the project beforehand. He also based this assumption on the fact that people might have certain expectations regarding the competencies of the robot, which could affect how they approach it for the first time.

Next, professor Purgathofer mentioned that people might interact differently with the robot depending on their mood that day. He suggested an interaction flow that would ask participants about how they would want to interact with the diary and ask about some common topics (2). These flow changes also imply that the robot might alter some words in its replies depending on certain situations. For example, the expert suggested to use "How was your lunch" if the time of the interaction is past noon (3).

Additionally to this topic, the discussion with the expert changed to the subject of the robot possibly learning from the human condition. He argued that a diary setting presents a more fitting opportunity for an AI to learn about human emotion. In this case, the robot could then adapt its questions to the user's diary entries and ask more appropriate questions about their daily life and previously mentioned topics (4).

Regarding the aspect of trust, professor Purgathofer mentioned that it would be interesting to split the participants into two groups and tell each one that the robot was made from a different manufacturer which would be a big tech company (5). He then proposed monitoring the participants' behaviour from that perspective and see whether there is a difference in the quality of their entries.

Also on the note of trust, the reviewer would have liked to know where the data is stored (6) and maybe hear it from the robot itself if that was possible, for example by saying "I stored your entry in a file named X". The same should be the case if the robot looked something up online.

When told about the intention of letting participants take the robot home with them and afterwards asking where they placed the robot, the reviewer agreed that it could lead to interesting findings.

4.2 Resulting changes to the robot

Based on the previous feedback some changes to the implementation of the robot were made. The following section looks at the additions to the robot's behaviour and to the plan of this work and discusses why certain review points were not feasible with this particular project. [1]

As a result of the first two pieces of advice received (1,2), the robot's interaction flow was altered as seen in Figure 3.4. When first starting the application and entering the diary mode by saying "diary", the robot responds with "Hello!". Immediately after that it asks if the user wants the robot to listen or if they are in the mood to chat. These two possible modes of interaction will later on be referred to as the "listening mode" or the "chatting" or "talking mode", respectively, throughout this work. If the user mentions the keyword "listen", the robot says "ok" and does not interfere with the user's text until

[1] Even though the work does not follow chronological order, the implementations that take into consideration the outcomes of the expert interview are presented before the corresponding chapter. This has the purpose of showing a complete picture of the implementation of the robot and explain the information that pertains to code in one place.

they say "exit diary", closing the application. However, if the keyword is not mentioned -in the assumption that the user answers something along the lines of "I want to chat"- then the robot will say "ok" and ask one of the two scenarios "ask about food" and "ask about work".

These scenarios will be triggered also if the user takes longer than 10 seconds to answer. Another assumption here is that the user does not know what to talk about, as suggested by the professor in the expert review. In the first scenario it will ask "What did you eat today?", in the second "How was work today?". If both questions were already posed, the robot will ask "Did anything else happen today?". This question will be posed again if the aforementioned period of silence is detected.

However, the robot does not change the words of the established interactions (3), as it was suggested by other sources that it should be either a user-tailored experience or a very general exchange. For example, if the robot asked "how was lunch" but the user does not usually have a meal at lunchtime, the user might get turned away from answering. However, the robot's behaviour was hard-coded throughout the entire study and did not allow the possibility of dialog history analysis or context awareness. Thus, since personalizing the interaction with the robot was not a feasible option, the questions asked by QBo were kept broad.

Moreover, as the robot does not use an AI and instead recognizes specific keywords to which it answers with hard-coded replies, there is no possibility of it learning from the user (4). An initial idea was to ask a set of questions to the users, such as "What is your profession?" or "What are your hobbies?" and asking fitting questions in later sessions. However, as the speech-to-text recognition software yielded poor results in initial testing when it came to the accuracy of the words, a misunderstood response might lead to frustrations on the part of the participants. Moreover, especially for queries with multiple answers (such as the second aforementioned question), the robot would not be able to identify all of them given a restricted pool of recognized words.

There were two major recommendations made to investigate the participants' trust towards the robot: splitting the participants into two groups and giving each different information regarding the provenance of the robot and letting the device tell them live how it stores its information. However, there are several limitations which were solved by making alterations to the questionnaire and pre-study phase, instead of making them in the implementation of the diary software. The foremost reason for this course of action is the restricted capabilities of the robot's software.

Firstly, the pool of participants was kept to four people with the focus on analysing their responses from a qualitative point of view. While the trust of a robot also depends on their provenance, there was concern regarding whether a small amount of participants could lead to meaningful findings (5). This issue was addressed in the study set-up by asking the participants about their views on big tech companies and what they expected to tell the robot in the following days. Afterwards, the participants were told that their data will not be sent to third parties and will be stored locally by the faculty for the

duration of the study. Then they were asked whether this changed anything in their expectation of the quality of their entries.

Secondly, as the robot would be used as a journaling device, there was a possibility that users might create entries multiple times a day. It was expected that it would be irritating to the users if the robot kept saying where it stored the participants' entries, as it would always be the same place (6). Instead, the participants were shown exactly where the robot stores every file so that they can go over their entries at any point.

According to the interaction flow presented above in Fig. 3.4, as well as its implementation detailed in chapter 3, the participants now had multiple ways of engaging with the robot depending on the mood they were in that day. Their experiences would be rated through a series of interviews and questionnaires, as well as through the quality and content of their daily diary entries. While the robot presented limitations in terms of speech recognition and context adaptability, the possibility of multiple interaction questions presented by the robot, as well as pointed questions regarding the participants' expectations of social robots and of the one used in the study were meant to make up for these constraints.

CHAPTER 5

Results of the participant study

As there are four participants in the study, they are looked at separately in the form of profiles, in order to underline any differences in behaviour or judgement towards robots before and after the study. The duration as well as basic information about each participant is written in the beginning of their profile. For all users different themes are identified in their pre- and post-study interviews. These codes emerged after analysing their answers as well as taking into account the contexts of the questions posed during the interviews.

Pre-study interview

The pre-study interviews were done before each participant's study period, in order to scope out their general attitude towards social robots and QBo especially. The following are the identified codes that are discussed in this section:

- *General impressions on robots* - This theme encompasses thoughts that participants have or had about robots and what the term "robot" means to them.
- *Possible uses of social robots* - As this work is looking at a social robot, participants were asked about which uses they could find for a social robot, whether they think it would be used in the future and how they would customize such a device to suit their needs.
- *Influencing factors on trust towards robots* - Another important topic is trust and participants expressed their feelings regarding factors that could in- or decrease their levels of trust towards a device, especially a robot, and whether they would accept any advice from a robot.
- *Impressions on the QBo robot* - After being shown the robot for the first time, participants described their first impressions regarding physical aspects and subsequent possible uses for the robot.

- *Emotions in robots* - Lastly, another theme was how participants would react to robots having emotions. While this aspect is not very relevant to the pre-study analysis, it ties in with the quality of the interaction with the robot during the study, as it gives certain responses depending on the day the user had.

Post-study findings

This section presents both the findings from the post-study interview with the participants, as well as evaluations regarding the entries they created during the study period.

- *Overall experience* - This section is meant to encompass the 4 participants' likes and dislikes, describe their interaction routine with the robot and its placement in their home. This section is also meant to include additional thoughts they might have had during the study, that were mentioned during the second interview.
- *Trust* - The "trust" code looks at questions where participants were asked about whether they felt any trust towards the robot and what they think could explain their behavior in this regard.
- *Outlook on the future of social robots* - Lastly, participants were queried on their expectations regarding the future of social robots and what they would personally wish for in a robot to increase their trust towards them.

Following these findings, participants' entries are shortly analysed in terms of quality of the content and possible expressed emotions towards the QBo robot. Additionally, both Godspeed questionnaire results are presented in the same table with the purpose of comparison between results. However, their analysis is also done separately for each user.

5.1 Participant 1

The first participant is a 25-year old Romanian architecture student who works in the same field and identifies as female. She had no previous experience with robots apart from her autonomous vacuum robot in her own home and does not keep a journal regularly.

5.1.1 Pre-study interview

The pre-study interview was conducted at the researcher's home, which is very well known to the participant, so it represented a familiar environment.

- *General impressions on robots* - Participant 1 (P1) viewed a robot as a mobile object that would be most useful in making human life easier. She was previously unaware of social robots and had a limited understanding of robots as surveillance or home management tools. The participant also thought that a more powerful

or complex robot requires a user who is more technologically savvy. She would give a robot in their home a name instead of a gender or role so that it could be addressed.

P1 understood the advantages of social robots as indicated in the item that follows, but she also expressed concern about the possibility that robots could become so customized to their users that they could retain our behavioural patterns, triggers, and responses. Subsequently, humans would become accustomed to interacting with a robot that comprehends their impulses and would find it more challenging to be social with other humans.

- *Possible uses of social robots* - The participant mentioned not having any need for an additional robot in their daily routine, but suggested that social robots could be used in old people's homes to help recoveries from memory loss. Working with persons who have trouble in social circumstances, such as those who are unable to recognize emotion or interpret social cues from other people, was another named use case.

- *Influencing factors on trust towards robots* - P1 was clear that she did not trust major digital companies like Amazon or Google, particularly in light of an earlier event in which they were secretly recorded. She would have been more inclined to trust a corporation, though, if it consistently provided clear information about how it handled personal data, supported by outside audits, and did so without using overly convoluted legal jargon. In this sense, P1 would not have put the robot in her room because it would make her feel spied on. P1 believed that younger generations are particularly affected by privacy issues because older generations do not use as many devices and do not have as much data at risk.

  If the robot could also spell out and justify the grounds for its diagnosis and suggestions, then the participant would have been more inclined to trust it with guidance regarding the monitoring of medical parameters (blood tests, fitness, etc.). However, P1 would rather have had a medical professional operate on her than a robot. Regarding mental health, P1 could not imagine substituting robot-assisted therapy for counseling sessions with a real person, but she could understand employing robots to help those with social difficulties better comprehend emotions.

- *Impressions on the QBo robot* - The participant used the adjectives "sleek," "playful," and "scary" to describe the QBo robot. She also anticipated that it would be put to use for home monitoring, making use of its eyes. Additionally, the body that P1 believed looked like a human torso appeared to be "puffed out". Although she would not have regarded the QBo as an authoritative figure, she would have expected to receive some sort of orders or directives from it, for instance while cooking or in public settings like customer service. On the other hand, P1 believed that it appeared "childlike", albeit a little unsettling because of the eyes.

- *Emotions in robots* - P1 stated that she would be taken aback if robots could have emotions and would prefer it if they could only display positive ones. Though she

was interested by the notion that robots might be taught about human emotions, P1 was also concerned that they could develop unpredictable behavior or even become hostile toward humans. The most emotive response that P1 would want to see in robots is them exhibiting happy emotions or responding positively to the user's input.

5.1.2 Post-study findings

Participant 1 kept the QBo robot for 4 days and utilized it plugged into her keyboard and monitor. As mentioned in the methods chapter, this presented the limitation that she had to unhook it every time she wanted to use her personal computer. She found this technique to be more time-consuming than using the VNC Viewer software, despite the initial setup process being simple.

Interview

It was noted throughout the interview that the participant frequently referred to the robot as a "he," despite the fact that it employs commands delivered in a female-sounding voice.

- *Overall experience* - The main reason P1 used the chatting mode was because she found the questions to be really useful while reliving the happenings of that day. Also, the listening mode occasionally made her feel bad because she thought she wasn't doing as much during those times.

  Prior to her partner's arrival at their shared residence, the participant would typically converse with the robot in order to avoid disturbing him. Additionally, she wrote her postings in the evening when she thought she could cover a lot of ground.

  The robot was initially set up on P1's dining room table. She then placed it on her desk next to her monitor and laptop because it suited her setup better and because she felt uncomfortable using it while she was eating. She believed that this positioning would serve as a reminder for her to use the robot at the end of the day as she uses the computer frequently. She occasionally even forgot that the robot was there because it was often hidden by a desk chair.

  Likes - The participant appreciated the design of the robot, particularly the colors and its weight. She also liked how its head would occasionally move, as if it was looking at her while they were speaking. She had no prior experience with robots, so she was pleasantly surprised at how simple the setup was. She also remembered being delighted when anything unusual happened to her since she could add additional interesting entries to the robotic diary.

  Dislikes - The participant did not appreciate the fact that she had to take breaks from speaking to the robot, in order for it to comprehend all of her sentences. This

issue was addressed in chapter 3 “Methods”. The listening interruptions disrupted the flow of the conversation and caused the participant to forget her talking points or generally made her give up on continuing to talk about a subject even though she felt like she wanted to tell the robot more about her day. Due to the need to speak loudly and her concern that her neighbors might overhear her stories, the participant felt as though she shared little with the robot than she would have otherwise.

Improvements - P1 would not have employed a robot of this size for journaling purposes, nor would she use one that has physical eyes, because the ones of the QBo robot became “unsettling” after a few days. Instead, in order to show emotion, she would have replaced the robot’s actual eyes with LED pictograph counterparts known as “emoticon eyes”. She also would have wished that the robot understood her Romanian accent better, as she felt that the API did not comprehend her well. The possibility of determining whether a user is repeating the same word three times in a row as a hearing error was a novel implementation that P1 came up with. She suggested that this would provide the robot the opportunity to learn from users, expand its training against more speech patterns, or add new words to its internal database. The ability to recognize events and automatically generate reminders based on them would have been an additional feature that would have been ideal for P1.

- *Trust* - The participant said that if the robot could employ features that would make her everyday tasks easier, such setting reminders for appointments or grocery lists, she would allow the robot to sync with other personal devices. She appreciated the possibility of the robot being more safe than a real diary, particularly if it was password-protected. Despite these security precautions, she would still be concerned that a business would be able to read her entries, thus she would ultimately choose a real journal over a robotic one. During the study period, the participant associated the robot with the researcher and thought of what she would tell them instead of the robot itself. As P1 ran out of things to say, she would stutter because she felt “a little nervous” talking to the robot. She believed that if she were given greater freedom to utilize it, her trust in it would grow.

- *Outlook on the future of social robots*

  For personal use - P1 stated that she would think about utilizing a social robot as she gets older and that her preconceived notions about them were changed by her engagement with a robot in this study. Furthermore, she said it helped her envision what a daily routine incorporating a social robot would look like.

  For general use - The participant believed it would be advantageous for talking robots to be calibrated to a person’s voice when they are first set up, so that users do not experience any difficulties when speaking to it. Although she preferred a real notebook to a robotic one, she considered a social robot created in collaboration

with therapists may be very helpful. Not only would it be able to ask more questions, but it would also be able to ask "the proper ones" based on what was said.

From a trust-perspective - P1 thought that robots ought to be able to assess the subject of a conversation locally, without being linked to the internet, and they ought to have a large database of words and phrases. She stated that being aware of this will aid users in avoiding making connections between the robot and the company that made it or considering the possibility that their data might be shared to and used by a third party. She felt that she would always doubt the intentions of the corporation behind it, lowering her level of trust in the gadget from the start, despite being aware that the device is acting as intended. Furthermore, she would have had no issue trusting the robot if she knew it well and did not have to overcome the aforementioned hurdles.

Journal Entries

- *Content* - P1 discussed her everyday responsibilities, including cooking and doing laundry, as well as her work-related tasks. She also told the robot about going to the doctor (without explaining why) and buying something new, describing the exterior to the robot.

- *Identified emotions* - The participant expressed excitement over recent purchases. She also stated feelings like being relieved when she had to work less than anticipated on a project or worried about the health of her and her boyfriend.

  The robot was frequently referred to as "you" by P1 (examples include "I don't know what else to tell you" and "I will talk to [the researcher] about you"). She also commended the robot for acting appropriately, saying "thank you" or "[you] smart cookie" when it understood her correctly after she repeated herself and tried to enunciate her words more clearly.

5.1.3 Godspeed questionnaire comparison

The comparison of the first participant's attitude before and after the study can be found in Table 5.1.

It is important to note that the participant gave the robot initial scores in the moderate to high range for "humanlike" characteristics like consciousness, likeability, competency, intelligence, and sensibility. She later gave the robot ratings of "machinelike," "artificial," and "fake" in response to her annoyance with the robot's speech-to-text API's latency. Overall, the differences between dispositions are slightly pronounced, especially on the scales "incompetent"/ "competent" (the robot appearing very incompetent at the end of the study) and "quiescent"/ "surprised" (as the participant stated that she sometimes forgot that the robot was there and felt uncomfortable by its eyes).

Anthropomorphism	Fake	1	2	3	4	5	Natural
	Machinelike	1	2	3	4	5	Humanlike
	Unconscious	1	2	3	4	5	Conscious
	Artificial	1	2	3	4	5	Lifelike
	Moving rigidly	1	2	3	4	5	Moving elegantly
Animacy	Dead	1	2	3	4	5	Alive
	Stagnant	1	2	3	4	5	Lively
	Mechanical	1	2	3	4	5	Organic
	Artificial	1	2	3	4	5	Lifelike
	Inert	1	2	3	4	5	Interactive
	Apathetic	1	2	3	4	5	Responsive
Likeability	Dislike	1	2	3	4	5	Like
	Unfriendly	1	2	3	4	5	Friendly
	Unkind	1	2	3	4	5	Kind
	Unpleasant	1	2	3	4	5	Pleasant
	Awful	1	2	3	4	5	Nice
Perceived Intelligence	Incompetent	1	2	3	4	5	Competent
	Ignorant	1	2	3	4	5	Knowledgeable
	Irresponsible	1	2	3	4	5	Responsible
	Unintelligent	1	2	3	4	5	Intelligent
	Foolish	1	2	3	4	5	Sensible
Perceived Safety	Anxious	1	2	3	4	5	Relaxed
	Agitated	1	2	3	4	5	Calm
	Quiescent	1	2	3	4	5	Surprised

Table 5.1: Godspeed questionnaire answers of Participant 1; ■ = pre-study answers, ■ = post-study answers, ■ = coinciding answers

5.2 Participant 2

Participant 2 (P2) is a 24-year old Austrian computer science undergraduate who is employed as a developer and tutor at the time of the study. P2 is a female who also identifies as such and has experience working with social robots from university courses. She occasionally uses a journal but not on a daily basis.

5.2.1 Pre-study interview

- *General impressions on robots* - P2 pictured a robot as a moving object with anthropomorphic traits, particularly features representing eyes. Personally, she preferred a smaller moving robot that could follow her around and had "round features" and big eyes. In terms of operability, the robot should be able to acquire data or set parameters that are specific to the user and be ready to use right out

of the box. In order to remind P2 to utilize the robot, it should be positioned somewhere in her line of sight. As she already had some experience with robot development, P2 stated that robots have certain limitations and that they are usually portrayed unrealistically in movies compared to the state of the art at this time.

- *Possible uses of social robots* - P2 was aware that robots could assist people socially because she had previously dealt with a robot created to help the elderly with emotions of loneliness. Furthermore, the participant emphasized that a robot should be used as a device to support people and not replace them. P2 could have imagined herself employing robots in the future in order to maintain contact with others as they got older, but saw no need for a social robot at that time. Depending on the nature of the engagement, P2 would distinguish between something they possess and something that is more valuable to them.

  According to the participant, communication skills should be improved in robots so that people may engage with them more naturally and integrate them into daily life. Robots should also have an effective speech recognition feature, as repeating oneself too many times would be frustrating. Otherwise, P2 argued that humans tend to have unrealistic expectations of robots and that people should accept them for what they are and show more patience with them when they make mistakes.

- *Influencing factors on trust towards robots* - P2 believed that it was challenging to achieve a clear separation between the owner company and the robot. If the robot asks intrusive inquiries, it could be perceived as overbearing, especially in conversational settings. While P2 would have appreciated it if the robot could get to know her better and provide a more customized experience, for instance when making suggestions about the weather, food, or directions, she would not have followed its advice on sensitive matters like relationships.

  She would have heeded a doctor's recommendation if it came from a human professional, but she would have objected if the robot started making assumptions about her. For instance, P2 would have been open to receiving some dietary advice, especially if she specifically asked for it, but she would have complained if the robot frequently or unpromptedly offered dietary advice because it implied the user had a weight issue. P2 also said that she would not typically have used QBo as a journaling tool but that she made an exception because she knew the creator and was aware of who was reading her daily entries.

- *Impressions on the QBo robot* - P2's first impression on the QBo is characterized by adjectives like "cute" and "fun," as well as the notion that it possesses a few "stereotypical traits" (referring to the head-shape and eyes). Because of the way the robot's eyes looked, she felt both thrilled and uneasy at the same time. This is another reason P2 would have placed the robot in the living room rather than her bedroom, where she would be reminded to converse with it about her day or any noteworthy events that had occurred in the past.

- *Emotions in robots* - In addition to the aforementioned ideas about having a discussion that feels natural, P2 preferred it if a robot could disagree with them on some topics or recognize when to listen to their complaints. This would make it seem as though she were conversing with a friend. P2 would not have been surprised if a robot started acting emotionally because she was aware that these are artificial and that robots are often created with humans in mind and programmed to behave as humans would expect them to.

5.2.2 Post-study findings

The second participant operated the robot in a five-day study period using the network and VNC account that were made available. The final day of the interview and the completion of the Godspeed questionnaire were both included in this phase.

Interview

During the interview, P2 made reference to the robot as being male, despite the fact that she had already recognized this and had corrected herself once by saying "she" and then "it."

- *Overall experience* - The participant expressed her gratitude for taking part in the study since she believed it had altered her perspective on the employment of social robots in the future. She first struggled to adjust to seeing the robot every day and hesitated to approach it. P2 remarked that the overall experience had increased her interest in incorporating daily journaling.

  She only used the robot's listening mode because she kept getting interrupted while it was in talking mode. She "taught" herself, nevertheless, to express whether she was having a good or bad day in order for the robot to respond and allow the participant to continue talking.

  Contrary to her expectations during the first interview, P2 placed the robot in her bedroom next to her door, in order to remind herself to complete the daily journal entry. In order to have more to say in her entry, she interacted with the robot in the late afternoon, generally just before turning in for the night.

  Likes - As the second participant became used to the QBo robot's behavior with the prolonged listening pauses, it prompted her to think more deeply about her day. She said that having to wait caused her to carefully consider the language she used in the entries and that she preferred speaking to writing down her ideas.

  Dislikes - She did not appreciate that she was interrupted during her story in the chatting mode, as it made her give up telling it wholly. She was also bothered by the fact that the robot did not understand her accent very well. Physically, the participant did not like the unblinking eyes, as she felt that they were "staring" at her and subsequently made her uncomfortable.

Improvements - In general, P2 hoped that the robot was more responsive to user input and more interactive when it was appropriate, for example whenever she was in the same room as the device or when giving particularly emotive responses. The term “appropriate” was also used to describe empathetic answers to the user’s remarks. She also would have preferred that the robot asked her other questions or questions based on information it had already obtained. She believed it would have improved her ability to reflect on her day and given her a sense of "appreciation," as if the robot had shown serious interest in it.

- *Trust* - At the end of the trial, the second participant felt that she had become closer to the robot, maybe in part because it had spent so much time in her bedroom. While she understood the effects of the robot’s head turn when the participant is speaking, it made her feel more surprised and anxious than trusting towards it. Ultimately she expressed that she did not believe the robot to be a conscious being, especially after being aware of its capabilities and subsequently did not place much trust in it. She also associated the robot with the researcher, which helped her overcome this issue during the creation of her entries.

- *Outlook on the future of social robots*

  For personal use - P2 would not have wanted a robot with multiple functions "so she can still do things for herself," including online searches. Instead of having to manually switch the robot on or check the accuracy of its speech-to-text inputs throughout the day, she would want it to be on all the time and used at random throughout the day. Also, because she felt that chatting instead of writing it all down seemed more natural, the participant would think about purchasing a social robot for journaling.

  In terms of the robot’s appearance, the participant would have liked one that had fur or was "fluffier" in order to resemble a pet. Also, she would have wanted its eyes to be smaller and blink more frequently so that it acted more realistically.

  For general use - She would see the appeal of social robots in society, especially for people who need someone to talk to, as they would be more interactive than a pet. This could potentially be advantageous in conversation scenarios, where people may need to participate in regular verbal exchange. The embodiment of the robot might also be more advantageous than creating an app, as it could result in greater engagement with the user.

  Despite the fact that technology is evolving quickly, P2 believed that several of the gadgets that are more common in the typical household today, such as Amazon’s Alexa, had persistent faults, particularly when they must execute actions like setting or deactivating an alarm. Because of this, the participant wishes that social robots would be employed in more delicate contexts, such as language learning or emotion recognition, as opposed to just assisting humans with daily tasks.

  From a trust-perspective - P2 would have been more likely to trust social robots if they had characteristics that made the robot seem more humanlike, such as speech

or movement that had an organic feel to it. She also believed that if the robot were to tell the user something about themselves, it would make them appear more human and relatable, which would improve user trust.

Journal Entries

Observing the second participant's entries as a whole, it is clear that she began by discussing mundane items of her daily routine before gradually adding more emotional language near the conclusion.

- *Content* - P2 provided the robot with broad information about her diet, employment status, and any household duties she intended to complete. As described in the interview, she included phrases like "good day" and "bad day", relying the robot's programmed response mechanism.

- *Identified emotions*- Furthermore, not only did she use a phrase like "good day", but she added "very", signaling a change in emotions and being generally excited. She began using adjectives after the third entry, such as "exhausting" or "I was very productive." In addition, she frequently concluded each post with "bye," even though this is not the directive for closing the journal.

5.2.3 Godspeed questionnaire comparison

From the comparison of the second participant's answers of the Godspeed questionnaire, which can be found in Table 5.2, it seems like the opinions before and after the study were very ambivalent.

For instance, in terms of anthropomorphism, to P2 after the study, the robot appeared to be a little more like a human, albeit more artificial and moved more rigidly. The participant liked the robot more in the end and found that it was more pleasant, even though it seemed more unfriendly and unkind. Additionally, by the end of the study, QBo looked more incompetent, ignorant and foolish to the second participant. It seems that the participant was at times rating her experiences with the robot and other times the impression the robot made on her.

5.3 Participant 3

A German business student who works full time aside from his studies was selected as the third participant (participant 3 (P3)). P3 is a 25-year-old man who often utilizes technology for self-organization and health tracking but has little actual experience with robots (much of his knowledge comes from television or movies). Instead of keeping a diary, he uses the information gathered to provide an overview of his well being.

Anthropomorphism	Fake	1	2	3	4	5	Natural
	Machinelike	1	2	3	4	5	Humanlike
	Unconscious	1	2	3	4	5	Conscious
	Artificial	1	2	3	4	5	Lifelike
	Moving rigidly	1	2	3	4	5	Moving elegantly
Animacy	Dead	1	2	3	4	5	Alive
	Stagnant	1	2	3	4	5	Lively
	Mechanical	1	2	3	4	5	Organic
	Artificial	1	2	3	4	5	Lifelike
	Inert	1	2	3	4	5	Interactive
	Apathetic	1	2	3	4	5	Responsive
Likeability	Dislike	1	2	3	4	5	Like
	Unfriendly	1	2	3	4	5	Friendly
	Unkind	1	2	3	4	5	Kind
	Unpleasant	1	2	3	4	5	Pleasant
	Awful	1	2	3	4	5	Nice
Perceived Intelligence	Incompetent	1	2	3	4	5	Competent
	Ignorant	1	2	3	4	5	Knowledgeable
	Irresponsible	1	2	3	4	5	Responsible
	Unintelligent	1	2	3	4	5	Intelligent
	Foolish	1	2	3	4	5	Sensible
Perceived Safety	Anxious	1	2	3	4	5	Relaxed
	Agitated	1	2	3	4	5	Calm
	Quiescent	1	2	3	4	5	Surprised

Table 5.2: Godspeed questionnaire answers of Participant 2; ■ = pre-study answers, ■ = post-study answers, ■ = coinciding answers

5.3.1 Pre-study interview

- *General impressions on robots* - When he thought about robots, P3 envisioned human-shaped androids with machine learning skills whose decision-making is devoid of human involvement. Otherwise, the participant stated that he believes we may be a long way from such capable and realistic-looking robots and that he prefers to think of them as an integral component of production processes, like the one the VW Company utilizes to build cars. Robots differ from phones in that they also have physical capacities, such as the ability to follow people around or observe their surroundings. P3 worried that analysing its environment may not be in compliance with the General Data Protection Regulation (GDPR).

  The participant believes that a device's generational differences have an impact on the abilities users require to operate it, particularly in terms of user friendliness. For instance, P3 contended that early gadget generations need users to comprehend

or learn more, and that users would benefit from prior knowledge of computational technologies or information systems. In contrast, succeeding iterations of a gadget are often improved to provide a better user experience and need fewer of the aforementioned abilities from its users.

- *Possible uses of social robots* - P3 highlighted nursing homes when asked about potential applications for social robots in society because he was already familiar with the "Paro" robot. Yet, the individual also highlighted a potential application by teenagers in the classroom. According to P3, pupils in German schools frequently have to attend lessons where they are taught responsibility, such as taking care of children, for which they must take care of an interactive doll at home as practice. The participant makes the point that under these circumstances, having a social robot that could potentially assess its users' tendencies and give customized tasks would be highly helpful. For instance, if a social robot were brought home to educate students how to care for a child, it might observe how the user acts in specific scenarios, such as not waking up at late hours, and instead increase the number of times it requires attention at night. On a personal level, P3 would like to have a robot that can be utilized for home automation as well as social interaction.

- *Influencing factors on trust towards robots* - On the topic of trust P3 seemed to be more specific about his behaviour. According to the participant, he would not have shared private information like his thoughts on various topics. He underlined, however, that " [...] it's not about the device itself, but it's about the corporation behind the device". In that regard, P3 stated that he would have more faith in robotics-focused research than robotics produced by major firms like Microsoft or Google.

  P3 trusted companies like Apple to gather information about his everyday activities since he considers himself to be a power user of home automation devices. He stated that while he would want to have automatic activities set up by the AI or receive personalized advice on how to improve his performance, he would also have been willing to contribute this information in order to enhance the general user experience of a product. He would have permitted a corporation to connect to multiple devices for each of these uses in order to expand the capabilities of his home automation system. Despite sharing tracking information (location, alerts, and orders), P3 would not have divulged professional or private information, especially for legal reasons.

  P3 reiterated that he wanted an automated setup in his house, such as correctly timed alarms or dietary counsel from the AI, when asked what advice he would want from a robot. Also, he would trust the robot to share data and provide financial trading recommendations, but only if he was informed of how the advice was determined and how his data was being utilized, also for legal considerations.

  According to the third participant, who recalled that when personal assistants like Siri or Alexa were first developed, people did not trust them, the concept of trust

is ultimately arbitrary. A few years later, P3 observed that he and others close to him are becoming more dependent and trusting on these helpers.

- *Impressions on the QBo robot* - P3 characterized the QBo robot as "cute" but "simple looking," adding that he did not anticipate it to be very capable. The participant identified the robot's purpose as educating children based on its outward appearance. P3 felt it helpful that the robot had a depiction of eyes as he was considering how he would engage with it in the future. He believed that this would allow him to concentrate when speaking with the robot.

- *Emotions in robots* - As the third participant is also accustomed to movies that portray very advanced robots, he would have been unfazed if a robot would start displaying emotions. While he sees no need for emotions in robots, he would prefer it if the robot was realistic looking, as he would then receive its responses more as emotive reactions. P3 mentioned that he would be wondering whether the robot is "smart" enough to draw its own conclusions about the user's emotions, and if so he would perceive the device's responses as an expression of emotion. Otherwise, P3 would not view the robot's behaviors as realistic and would like interacting with it less if they were obviously hard-coded.

5.3.2 Post-study findings

Because of his familiarity with the VNC program, the third participant found it more convenient to operate the robot using it.

A total of 5 days were spent with the robot by the third participant. He used the robot as a daily check-in opportunity to evaluate his day rather than a journal as he often tracks his day using applications on his phone.

Interview

The robot was regularly referred to as "it" by the third participant. Additionally, he said that generally speaking, he did not understand the appeal of a robot with "unnecessary" physical features (such as eyes or arms, if they had no use); he would have high expectations of devices with high affordance and would be disappointed if the exterior would suggest a more capable robot than it actually is.

- *Overall experience* - The third participant explained that he enjoyed the act of journaling and had begun to give it more thought than before, but he would still not have done it on a regular basis. Instead of keeping a regular notebook, he may have wanted to think about obtaining a trip journal to record noteworthy, unusual happenings.

  Just like he stated in the first interview that he would not like pre-programmed replies, he mostly employed the listening mode. The third participant behaved

as though the QBo robot was more of a “platonic acquaintance”, keeping his descriptions of his day brief for example.

The robot was placed on the participant’s desk next to his PC, since he considered the creation of diary entries "more as an after-work activity". He had to remind himself to use QBo since, after 4 days he still had not made it a habit.

Likes - P3 discovered that the robot was ideal for quick journaling sessions, particularly when used in listening mode, which allowed him to reflect on whichever topics he wanted to and for how long he liked each day. The third participant felt that, given the robot’s predictable behavior, the provided small collection of questions and responses was very helpful.

Dislikes - P3 was at first confused regarding the topics to discuss with the robot and its behavior. As was already noted, he anticipated that the robot’s eyes or head would also be utilized to show its emotions. The third participant similarly did not like how stiff the robot was, both in terms of mobility and capability. He stated that he would have wanted for the robot to always stay on and listen for keywords, but he swiftly added that doing so would have violated the GDPR and he would also not have approved.

Improvements - That being said, P3 would have liked the robot to memorize interactions and ask other questions or give different answers based on previously gathered information. He also would have liked the robot to be able to take over certain tasks, for example by integrating it with his phone or by connecting it to other home devices. As he would have appreciated it more if it was always turned on, provided it did not pose a GDPR issue, the participant listed possible alternative keywords, such as "I want to talk to you" or "Can you hear me?", through which the robot could have understood that the diary application should be opened.

- *Trust* - The third participant mentioned that even though he wanted the robot to have more capabilities, he would always question its intentions (or those of the corporation behind it) if they required an internet connection. He stated that through internet connection there would always be the possibility of a malicious third party gaining access to it and stealing users’ data.

- *Outlook on the future of social robots*

  For personal use - P3 did not believe that he would use a robotic diary in the future, but he stated that he could better see himself use a social robot after this experience. In general, he stated that he would prefer a robot that could assist him in better automating his everyday tasks and duties, but he would value it if it had more social features.

  For general use - The participant understood and supported the use of a social robot, especially in situations where the user is very lonely and the robot could provide conversational interaction possibilities. One example would be elderly people who require the linguistic exercise and wish to keep track of their days.

Also, he noted that they may be used more frequently in classrooms, for instance, with young children who have speech difficulties or who are studying fundamental grammar or foreign languages. As robots could look increasingly more like humans, P3 would also expect functionalities or traits that pertain to human intelligence rather than simple listening devices.

From a trust-perspective - The participant's main concern about robots at this point was their internet access. He hoped that robots will not be as dependent on the internet in the future as they are now, and that they would only use it for essential things like upgrades. If this was the case, or if robots were able to recognize when they were being attacked by malevolent individuals, P3 believed that he would have more faith in such devices.

Journal Entries

Overall, it appeared as though the third person was speaking to the robot in a professional way, using complete sentences and connecting terms like "unfortunately" and "nevertheless." He also appeared to be debating over what he was doing. For instance, he argued : "I have to wait until he is finished" when he acknowledged being behind on a project at work due to a coworker. He also said to the robot, "I have a long night ahead of me," adding, "[but] this is not a problem because I have slept well."

- *Content* - P3 mostly discussed his work's quality or the tasks that needed to be completed with the robot. Without directly mentioning his employment or the specific issue, he appears to be attempting to convey to the robot what his work entails. For instance, he informs QBo that "the product is practically done and only the final touches are remaining," without going into explicit detail about the subject of the project.

- *Identified emotions* - The third person spoke generically without expressing any clear feelings toward the robot. He conveys his excitement for the tasks at hand with terms like "[feeling] extremely energized," yet he does not appear to address the robot directly or as a separate entity.

5.3.3 Godspeed questionnaire comparison

P3 was generally of the same opinion before and after the study with minor deviations, especially regarding anthropomorphism and likeability. The results of the Godspeed questionnaire can be found in Table 5.3.

The third participant saw the robot as more "natural", "humanlike" and "conscious" at the end of the study, but mostly kept their opinions on animacy, like the robot behaving neither "lively" nor "stagnant" and rather "artificial" and "apathetic". While P3 liked the robot more and found it nicer in the end, he thought it acted less kind than initially expected. A stronger discrepancy is seen when comparing the participant's perception

Anthropomorphism	Fake	1	2	3	4	5	Natural
	Machinelike	1	2	3	4	5	Humanlike
	Unconscious	1	2	3	4	5	Conscious
	Artificial	1	2	3	4	5	Lifelike
	Moving rigidly	1	2	3	4	5	Moving elegantly
Animacy	Dead	1	2	3	4	5	Alive
	Stagnant	1	2	3	4	5	Lively
	Mechanical	1	2	3	4	5	Organic
	Artificial	1	2	3	4	5	Lifelike
	Inert	1	2	3	4	5	Interactive
	Apathetic	1	2	3	4	5	Responsive
Likeability	Dislike	1	2	3	4	5	Like
	Unfriendly	1	2	3	4	5	Friendly
	Unkind	1	2	3	4	5	Kind
	Unpleasant	1	2	3	4	5	Pleasant
	Awful	1	2	3	4	5	Nice
Perceived Intelligence	Incompetent	1	2	3	4	5	Competent
	Ignorant	1	2	3	4	5	Knowledgeable
	Irresponsible	1	2	3	4	5	Responsible
	Unintelligent	1	2	3	4	5	Intelligent
	Foolish	1	2	3	4	5	Sensible
Perceived Safety	Anxious	1	2	3	4	5	Relaxed
	Agitated	1	2	3	4	5	Calm
	Quiescent	1	2	3	4	5	Surprised

Table 5.3: Godspeed questionnaire answers of Participant 3; ■ = pre-study answers, ■ = post-study answers, ■ = coinciding answers

on competency: QBo seemed more "incompetent" in the beginning, but after the study it gave P3 an impression of increased competency. Lastly, the participant was also more surprised by the robot in the end.

5.4 Participant 4

5.4.1 Pre-study interview

Last but not least, participant 4 (P4) is a 25-year-old Austrian male computer science student who has expertise developing a robot arm and additionally works as a software developer. He himself does not have a personal assistant like Siri or Alexa and does not feel the necessity to do so. Instead, he makes an effort to keep a physical diary and writes in it at the end of each day.

- *General impressions on robots* - Robots, as opposed to computers or personal assistants, are mechanical objects that can move on wheels or certain prosthetic legs, according to P4. Another feature that robots should have is a functional task to fulfill or a functional purpose (for example cleaning robots), otherwise, P4 would not consider owning one. He would currently find some activities interesting or helpful if a robot performed them, such as sending out smart reminders depending on the user's preferences and keeping an eye on a pet. Yet, the participant also pointed out that applications may take their place. Moreover, P4 mentioned that, based on his interactions with ChatGPT, an advanced artificial intelligence (AI) chatbot, the conversation with robots has the potential to be quite sophisticated. During the interaction with ChatGPT he was sometimes under the impression that he was talking to a very knowledgeable person, until the AI gave some wrong facts and reminded the participant that it is flawed.

- *Possible uses of social robots* - P4 believed that social robots can be really beneficial for those who are lonely or lack social interaction and would have considered utilizing one if he were in such circumstance. On the other hand, if consumers truly require therapy, a robot like this should not take the place of a therapist. Although the participant thought that individuals "should not need an extensive technical background for a good social robot", he also admitted that the first setup phase may be a little challenging since users are still evaluating its capabilities. The robot should capitalize on the first surge in interest by asking users about their preferences, specifics, and other information that will enable them to customize the robot to their tastes and enable it to ask more individualized inquiries down the road. While the participant felt the robot should be able to understand its environment and communicate when it thinks it is suitable, personalizing might potentially take the shape of reminders or observations (not too often and only when the user is in the room). P4 thought that a social robot should be created as a companion rather than merely a tool, for instance by using its physical traits.

- *Influencing factors on trust towards robots* - The participant would have been more likely to trust a social robot if it provided advice or information based on verifiable facts or on its own, if the robot explained how it arrived at those findings. Whether or not the robot's manufacturer is a major tech corporation was irrelevant to P4, who believed that if the he had any knowledge worth stealing, he would either not have shared it or would have known about it. He would have shared the same information with a social robot as he would with a stranger, therefore he would not view it as a "real" companion. P4 expected to need some time to warm up to a robot in order to talk about more intimate information with it and would feel more attachment to it if he was the one who built it.

- *Impressions on the QBo robot* - He used the word "cute" as his first adjective to describe the QBo robot, adding that he found the robot's tilted lids on the eyes to give the impression that it was enthusiastic or energetic. He was accurate in

his assumption that the robot was designed for teaching children based on this characteristic. P4 anticipated that the robot would always be turned on, listening for vocal cues from the user, and that he would only speak briefly to summarize his day's events or express his gratitude.

- *Emotions in robots* - While feeling lonely, the fourth participant would especially have wanted to hear encouraging input from the robot that included statements like "Everything is going to be fine." Even though he did not see the benefit of robots expressing emotions beyond that, he would have wanted them to exhibit emotional reactions physically as well, such as jumping if startled or shaking their heads in response to a negative answer. P4 required input from someone he knew would relate to him based on their own experiences, therefore he would not have heeded the robot's advice on intimate matters like relationships. That being said, the participant would still have wished to hear the robot's counsel since it could have motivated him to act or encouraged him to consider his experience from a different perspective. P4 also thought that giving advice might be difficult since it could easily make the recipient feel bad about themselves if delivered wrongly.

5.4.2 Post-study findings

The fourth participant used the provided VNC account to control the robot and held on to it for 5 days. As he had experience with the Raspberry Pi operating system, he had little difficulties setting up the robot, except for connecting it to the internet, as it kept providing a new IP address.

Interview

During the interview, P4 thought about the robot's potential and contrasted it with his physical notebook. In keeping with the first interview, the participant said he would rather assume that individuals who are coping with loneliness employ social robots. He also said that because he was not currently experiencing any problems, he would not require a robot for these purposes.

Throughout the conversation, the fourth person continually referred to the robot as "it."

- *Overall experience* - P4 initially compared the diary application to a voice recording app, stating that apart from the transcription process and some answers from the robot, it was not very different.

  He would not have minded if the robot displayed more emotions, as he felt that it would have given the device more character. He claimed that a more enthusiastic answer would have increased his excitement for the engagement with the robot and given him the idea that he was speaking to a human rather than a machine, particularly in light of his experience with ChatGPT.

The participant used the chatting mode when he did not know what to talk to the robot about. Otherwise, he preferred the listening mode overall, because it came naturally to him to talk to the robot uninterrupted for a longer period of time. However, P4 thought that his choice of interaction mode would ultimately depend on the busyness of the day or the week he was having. QBo was placed next to the bed on the participant's nightstand. He said he grew accustomed to seeing the robot every day in his flat and wrote entries before going to bed since he follows a similar schedule with his physical diary.

Likes - Conversing with the robot was simpler and more natural than writing everything down, so the participant preferred this method over keeping a physical notebook. In contrast to the physical diary, where he typically forgets to make entries every day, he also noticed that he did not miss any entries and completed them on time with the robot. Other than doing it as part of the study, he thinks the main reason for this was how simple it was to create an entry. The participant found vocal cues to be a natural method for operating the diary application. When he was under pressure or when he was stumped for conversation, he preferred the chat mode's questions since he considered them to be pertinent and useful.

Dislikes - P4 struggled with the robot's speech recognition and found it especially irritating when it misunderstood orders like "exit diary" or "listen." Although the chatbot's inquiries were appropriate, the participant would have preferred for the robot to base its responses on his input and provide context-dependent, adaptable answers. He believed that if the research had lasted longer, he would eventually have found the questions to be too monotonous.

Improvements - The fourth participant believed that contextual reactivity and the other listed dislikes were what eventually led him to regard QBo as a machine rather than a social robot, hence these were the most crucial areas for development. More practical functions, as well as greater movement and tangible input from the robot, would have been welcome. P4 wanted the robot to be able to do things like provide reminders or a rundown of the day ahead that included the weather and the calendar. According to its characteristics, the participant would have wanted the robot's physical size to be smaller or less "present" in the space.

- *Trust* - P4 would have trusted the robot with personal information, especially if the purpose behind data collection was to improve the quality of the interaction in the chatting mode. The fourth participant felt that emotional responses from the robot would have increased his trust towards it, as it would have given him the impression that the device cared or wanted to know more about him.

- *Outlook on the future of social robots*

  For personal use - After the study, the participant did not feel the necessity for a social robot, as he believed that they are best used for overcoming loneliness issues and felt that he would be reluctant to purchase such a device in the future

as well. The main reason for this would be that he would eventually miss human interaction.

For general use - Otherwise, he believed that children could benefit from a social robot that could teach them social skills or help them express themselves better. Even though such a robot could well be used by a family or for multiple situations, P4 does not expect social robots to become household staples, such as Amazon's Alexa, as he has observed how such devices are not very common, even though they have features that could be useful for many types of users and needs.

From a trust-perspective - The fourth participant said that one of the key steps to earning people's trust would be to demonstrate humanlike qualities, such as empathy. He compared future social robots to well-known droids from science fiction films, where the robot strives to assist people by being there for them, showing interest in them, and learning from them. He thought that these qualities would enable social robots win people's trust.

Journal Entries

P4 described replacing his diary with the robot, which means that the quality of the entries resemble the least that of his usual physical entries.

- *Content* - The participant talked about going to work, focusing on a school assignment, attending the opera, and picking up an old game. He did not go into any depth about either of these occurrences.
- *Identified emotions* - There were no identifiable emotions displayed in P4's entries, neither towards occurred or future events, nor towards the robot. The participant merely recited, without any suggestion of emotion, the happenings of his day.

5.4.3 Godspeed questionnaire comparison

The fourth participant's entries in the Godspeed questionnaire before and after the study can be found in Table 5.4.

Overall, it is evident that following the research, P4 frequently gave the robot 1–2 points fewer than his original score on the first questionnaire. In the areas of likeability and perceived intelligence there are noticeable variances, with QBo coming off as more mechanical, unkind, unpleasant, incompetent, and irresponsible than was previously anticipated.

The participant's perception of his safety was also unaltered, and he seemed to be both calm and agitated during his engagement with the robot in addition to being relaxed and surprised.

Anthropomorphism	Fake	1	2	3	4	5	Natural
	Machinelike	1	2	3	4	5	Humanlike
	Unconscious	1	2	3	4	5	Conscious
	Artificial	1	2	3	4	5	Lifelike
	Moving rigidly	1	2	3	4	5	Moving elegantly
Animacy	Dead	1	2	3	4	5	Alive
	Stagnant	1	2	3	4	5	Lively
	Mechanical	1	2	3	4	5	Organic
	Artificial	1	2	3	4	5	Lifelike
	Inert	1	2	3	4	5	Interactive
	Apathetic	1	2	3	4	5	Responsive
Likeability	Dislike	1	2	3	4	5	Like
	Unfriendly	1	2	3	4	5	Friendly
	Unkind	1	2	3	4	5	Kind
	Unpleasant	1	2	3	4	5	Pleasant
	Awful	1	2	3	4	5	Nice
Perceived Intelligence	Incompetent	1	2	3	4	5	Competent
	Ignorant	1	2	3	4	5	Knowledgeable
	Irresponsible	1	2	3	4	5	Responsible
	Unintelligent	1	2	3	4	5	Intelligent
	Foolish	1	2	3	4	5	Sensible
Perceived Safety	Anxious	1	2	3	4	5	Relaxed
	Agitated	1	2	3	4	5	Calm
	Quiescent	1	2	3	4	5	Surprised

Table 5.4: Godspeed questionnaire answers of Participant 4; ■ = pre-study answers, ■ = post-study answers, ■ = coinciding answers

CHAPTER 6

Discussion

The participant profiles will be compared in the chapter that follows in terms of the likes and dislikes of their experiences, actions, and viewpoints. Both sub-chapters will examine these traits before and after the study period with the robot, respectively. Lastly, an overview of the Godspeed questionnaire results will be analysed, in order to gain insights into their collective viewpoints on the QBo robot. The findings will be supported with existing literature, where possible, and potential arguments for the causes of these outcomes presented.

6.1 Similarities between participants' experiences

An overarching similarity among the participants was that during the interviews they stated that they could imagine social robots being suitable for various tasks, such as teaching neurodiverse individuals social skills, children responsibility or helping the elderly recover from memory-loss issues. Because some participants had not heard the term "social robot" prior to the study, as described in chapter 3, the "Paro" robot was shown to them, in an effort to showcase a social robot and give a better impression on the possibilities of a social robot. As this robot is one for helping the elderly overcome loneliness issues, some participants mentioned that retirement homes could also benefit from using social robots.

However, when asked again about possible uses of social robots in the future after their interaction with the QBo robot, all stated primarily that social robots could be employed for overcoming loneliness or for therapy. The essence here lies in the changes of their perception before and after the study, as it could imply that the participants saw the act of talking about their day to a robot as a social interaction, rather than a platonic exchange with a device. While using social robots for coping with loneliness has been indeed confirmed to have possible significant positive outcomes in elderly care (Pino et al., 2015), it would be interesting to assess to what extent participants considered the

interaction with a robot (even one with no dialog history analysis or dynamic outputs) a social one.

As discussed in the following sections, there were discrepancies between the exhibited levels of attachment among participants, but the claim of using social robots "when you don't have anyone to talk to" (as said by P4) was also made by participants who showed no clear emotion towards QBo. Indeed, there is literature that argues that there is great potential in employing robots for helping people overcome feelings of loneliness (Ananto et al., 2020; Ananto and Young, 2021). In these works it is underlined that people can escape feelings of loneliness through social interactions mediated by technology, for example call centres, mobile phone applications or chat bots. As lonely people tend to anthropomorphise social robots more than the rest, they also perceive the interaction with such a device more as a social one than a less lonely person would. While the participants of the study did not mention anything about being lonely (or, on the contrary, denied needing a robot for loneliness at the time of the study), these findings could support the claim that they perceived the robot as a truly social partner, especially given its conversational abilities. The latter paper (Ananto et al., 2020) also underlines the benefits of having a social robot in a domestic setting and how it could help in situations where the user experiences feelings of loneliness.

6.1.1 Pre-study

Participants P1, P2 and P4 all stated in the first interview, that they believe a robot to be a moving entity, supported either by wheels or other mechanisms. What is interesting is the fact that P4 was at that time working with a stationary robotic arm, and he still thought of positional movement first. This might be a consequence of widely employing robots for chores where they have to move in an enclosed space, such as vacuum robots.

When asked how participants would describe the QBo robot used in the study and what its purpose was, all of them correctly assumed that it could be used to interact with children. A common word that was used was "cute" by P1, P2 and P3, also "happy" and "energetic" by P4. When asked about the reasoning, all of them referred to the robot's eyes, more specifically its upturned eyelids. P2 and P3 additionally described it as "stereotypical-looking", referring to the fact that it has humanoid traits often found in robots.

None of the participants expressed that they would follow a social robot's advice on personal matters such as relationships, except for P4 who showed interest in a computationally-reached system of beliefs. However, they would take a robot's advice if it was supported by facts, which the robots could state to assure their validity. Some named examples include medical advice based on tracked health data or financial trading advice based on determined patterns across the user's and others' trading behavior. This belief might be due to the fact that people see robots as being able to synthesize more factual information than humans could (Brennen et al., 2020), which could also influence their assumption that robots have a more logical-mathematical type of intelligence.

Also on the same question regarding expectations about the use of social robots in the future, P3 and P4 expressed that they would want such a robot for home automation and would want it to learn patterns or behaviors from the user. P1 and P2 also mentioned a similar opinion and further specified that they would not want robots to replace humans but instead support them. Such comments might suggest that users would account for the level of human contact they would get if a robot was integrated into their homes.

6.1.2 Post-study

The most common frustration among all four participants was the robot's inability to understand them correctly. Some participants (P1 and P4 in particular) repeated words or phrases until the robot understood them right, while another participant (P2) got discouraged to tell the story further or as lengthy as they would have intended to. While these expectations are valid, it has been shown that personal assistants generally have little success when transcribing English words with foreign accents (Zamora, 2017).

Additionally, participants wanted to receive more context-aware questions and reactions to their entries. P4 also mentioned that he would have found physical reactions interesting as well. Another likely cause was pointed out by P3 who stated that if he saw certain capabilities in a robot, he would expect to engage with them during his interaction with the device. This could potentially mean that participants expected the capability not only to be offered by the robot, but be perfected. Setting high expectations based on a social robot's exterior features is also prevalent in the work by Kwon et. al, where the researchers suggest that robots placed in social settings receive generalised expectations. (Kwon et al., 2016).

Another similarity, which was identified in the interviews of P2 and P4, was that they specifically mentioned finding the act of talking to the robot easier and "more natural" than writing their entry in a physical journal. P3 also mentions something about it being somewhat easy to operate the robot. These statements could imply that, not only did they see the act of talking to the robot as a social interaction as concluded above, but participants also enjoyed the simplification of the act of journaling by using the robot.

P4 mentioned the fact that the robot does not use its eyes at all during the interaction with the user. All other participants agreed that they came to dislike the eyes at the end of the study, either finding them unsettling (P1, P4) or wishing that they blinked more (P2), which might be connected with each other.

While the robot's position in the participants' apartments is subjective as it depends on each layout, it is worth mentioning that P2, P3 and P4 placed the robot in their bedrooms. All participants placed QBo in a frequented spot where they would be reminded to complete their entries. P1 and P3 placed it on their desks, P2 placed it next to her bedroom door and P4 placed it on his nightstand. This could be in part due to the fact that the participants had a limited time with the robot and instructions to complete entries on a daily basis, however P4 also kept his physical journal on his nightstand and P3 mentioned the interaction with the robot being an "after-work activity" to him. It

would be interesting to investigate whether participants would have changed the robot's placement if given a longer period of time or if they had ownership over it.

Lastly, all participants said that they felt more sure about using social robots after having participated in the study. Taking into account all similarities and conclusions mentioned above, as well as the Godspeed questionnaire comparisons presented in the following section, it would be plausible to think that the participants who have never interacted with a social robot themselves prior to the study were unaware of its potential. As they seemed to have tempered their expectations of the QBo robot, they also understood its capabilities better and, coupled with the fact that most of the participants (P1, P2, P3) mentioned not trusting big technology corporations but trusted the researcher behind the study, they seemed to be more open to the idea of using such robots personally in the future again.

6.2 Differences between participants' experiences

There were also many differences between the participants' answers and experiences with the QBo robot, as presented below.

6.2.1 Pre-study

When asked what they would think about robots displaying emotions, almost each participant had different answers. P1 would not have been surprised if robots would display emotions, but would have preferred that they were only positive ones. P4 had a related response, but mentioned that the emotions could be displayed physically as well as verbally, to give a more organic impression. Addressing emotional topics and giving the belief of an emotional intelligence is a known expectation that people have of chatbots (Zamora, 2017). P2 wanted a display of both positive and negative emotions and having a back-and-forth with the robot on certain topics, but would have favoured counterarguments to negative responses, as these could be harmful in the future. Lastly, P3 stated that there was no need for robots to display emotions. These differing opinions can also be supported by the participants' behaviors exhibited after the study.

Another difference between participants' attitudes is their main concern regarding trust towards robots. While P1, P2 and P3 stated that they would generally be afraid that the robot manufacturer would steal personal data, P1 further mentioned that it would rather be young to adult people who would be affected, as opposed to elderly people who do not use technology much. P3, on the other hand, was more concerned with the legal implications of telling the robot information about their work and how that information could be used against him and his workplace if a third party maliciously gained access to it. Comparatively to these three participants, P4 said that he had no issues, as he believed that if a corporation wanted to steal their personal data they would have done so already. One plausible reason for these different attitudes could be the various backgrounds of the participants. As mentioned in the previous chapter, P3 was

an economics student, meaning that he could generally be more attentive to the legality of different actions and protocols. P4 was a computer science student, who might have been careful about what data he shared with third parties in the first place and so would have little reason to be concerned about the distribution of information he willingly gave away. Of course, these are speculations about the participants' subjective views which would need to be followed up on and would beg the question of why P2 did not share P4's views as she was also a computer science student at the time.

On the physical aspect, P1 was the only participant who, after describing QBo as "cute", saw the robot as a possible authoritative figure based on the forward-leaning chest. She said that it could also be suitable for giving instructions and could thus be employed in a public space as a customer support figure. This is also verified by her initial scoring of competency in the Godspeed questionnaire, as she awarded the robot a rating of 4. However, the participant gave the robot a score of 1 after the study in accordance with the idea that people can change their expectation of a robot after experiencing its capabilities (Kwon et al., 2016).

6.2.2 Post-study

Very notable differences can be seen in the participants' attitudes and displayed emotions towards the robot. While P3 and P4 seemed to lack any emotion when talking to QBo, P1 and P2 talked directly to it, addressing it with "you" or praising it when it understood them correctly, for example P1 saying "you smart cookie" after repeatedly being misunderstood by the robot. Moreover, P3 and P4 also referred to the robot with "it", whereas P1 and P2 used "he" instead. However, there is no evidence to suggest that they deemed the robot particular scores due to its perceived gender by either of the participants, as underlined in other works as well (Bryant et al., 2020).

This begs two foremost questions: Firstly, what is the difference between P3, P4 and P1, P2? Apart from their identified gender, P3 and P4 being male and P1 and P2 female, were there other traits that made them attribute different levels of emotions towards the same robot? Secondly, it is surprising that P1 and P2 primarily referred to the robot as "he" even though it employed a female voice for the diary application. This could be followed up with investigation on whether the appearance of a robot was more overpowering than its voice and what physical traits led the participants to associate the robot with a male gender.

Similar research has been done on the topic of willingness to comply with a robot if it has a mismatched attributed gender with the gender of the used voice in learning environments (Reich-Stiebert and Eyssel, 2017). However, the researchers suggest that even in non-learning environments, these traits can lead to an increased acceptance of the robot by users, as well as influence their perceived interaction with it. Matching gender to certain physical traits has also been shown to prove a challenge, especially as one needs both components to form a complete image of their expectations of the robot (Mcginn and Torre, 2019). Voice design should thus be considered more in future research, as this

research and the aforementioned works prove that a mismatch between the perceived gender of a social robot and its attributed voice can have significant influence on the behaviour of users with it.

It is also noteworthy, that P3 did display one alternative behavior, namely explaining his day to the robot. While he mentioned understanding that the robot had hard-coded responses, he took the time to explain his activities and thought processes to the robot, such as having much to do but having slept well.

There were further discrepancies regarding what these participants stated they would need in order for a social robot to gain their trust in the future. P1 and P3 would have preferred it if the robot had no connection to the internet and thus no possibility of any malicious third party stealing their personal information. P2 would have appreciated it if the robot would tell the user about itself, appearing to make a genuine connection with the user and confiding in them. Furthermore, P4 would have liked the robot to display humanlike emotional traits like empathy towards the user. These last opinions are supported by Langedijk and Ham, who state that using empathy and dialog history analysis in a robot can be powerful factors in persuading and advising humans (Langedijk and Ham, 2022).

The participants' interaction mode with the robot also varied: P3 and P2 were both partial to the listening mode, although the latter participant trained herself to mention having good or bad days in order to receive an answer from the robot and thus interact more with it. P1 liked the chatting mode instead, as it helped her identify subjects for her diary entries. Instead, P4 said he used both interaction modes and that his choice would depend on his day. However, he mentioned that using the listening mode came more natural to him and he preferred talking uninterrupted for the duration of his entry.

6.3 Godspeed questionnaire comparisons

The participants' similarities and differences in attitude can be seen when collectively comparing their answers to the Godspeed questionnaires. The two comparisons can be found in Fig. 6.1 and Fig. 6.2 for the pre- and post-study questionnaires, respectively. They are displayed in the form of box plots, in order to showcase the participants' overall tendencies, as some views strayed from the general average due to representing subjective experiences. However, as there are only four participants in the study, this representation is quantitatively little expressive.

Prior to the study, participants generally expected or described the robot to be rather "kind" and "pleasant", "responsible", "knowledgeable" and "competent". *Positivity bias* is a relatively old term which refers to the idea that people who have little experience with robots tend to trust them more (Dzindolet et al., 2003). This initial trust in a robot's automated decision process also seems to hold true when people are informed beforehand on how the device might make a mistake in its recommendation, according to Dzintolet et. al.

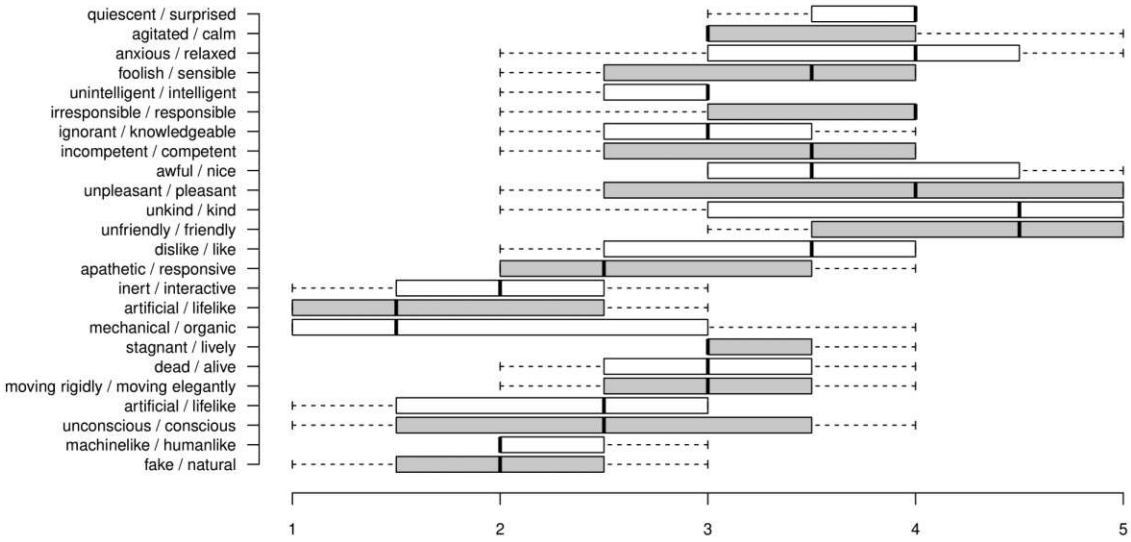

Figure 6.1: Godspeed questionnaire results of all participants before the study period

Otherwise, it also looked "artificial" and "mechanical", rather "unconscious" and "machinelike". This could be due to the fact that the QBo robot features few humanoid traits such as physical eyes. As the mouth and the nose are represented by LED lights and the body and shape of the robot show no complex features, this also could have influenced their perception of the robot not looking humanlike. They had neutral responses regarding the liveliness and how organic the robot's movements are. The latter rating is expected, especially because they had not yet seen the robot's movement capabilities and recognized only that it was stationary.

Participants' ratings dropped in the categories "perceived intelligence" and "likeability" after the study. The biggest notable difference is the competency of the robot, which initially was rated 3.3 on average, and was afterwards rated 1.7. This corresponds to the participants' wish that the robot displayed more features or had at least a better voice recognition software. Having such advanced capabilities, especially regarding administrative tasks and dialog history analysis is a common expectation of chatbot technology (Zamora, 2017). Moreover, people tend to have high expectations of social robots in general and temper them to a realistic level after understanding the robot's capabilities better (Kwon et al., 2016).

Otherwise, more participants stated to be more calm and relaxed after their interaction period with the robot. Getting more accustomed to a robot's capabilities can increase the perceived safety towards it, as well as strengthen feelings of trust (Akalin et al., 2022). This conclusion is also supported by the high level of transparency that was shared with the participants, in that they were informed beforehand about the fact that their data was being stored locally on the robot and how and where it was stored.

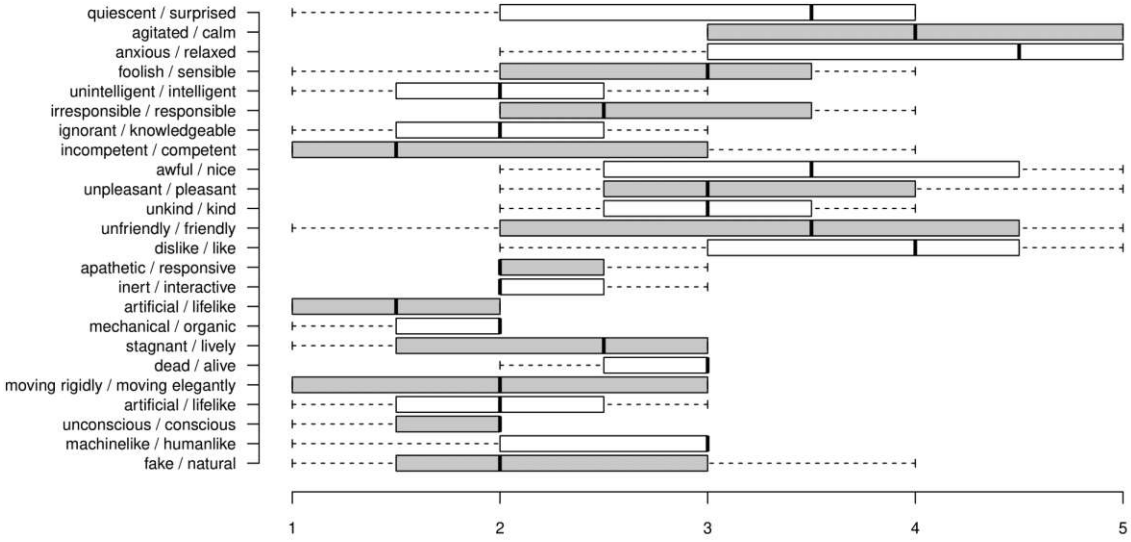

Figure 6.2: Godspeed questionnaire results of all participants after the study period

6.4 Discussion of the research questions

The first research question posed in the previous chapters was "What are people's expectations or concerns in the design of social robots in private contexts?". The most important aspect that needs to be underlined is that all participants mentioned that they could not separate a device from its owning company. Especially the first three participants said that they were concerned with a corporation stealing their personal data and would have issues with creating in-depth journal entries if the robot used in the study was not operated by a trusted researcher. This would be the first hurdle to overcome when asking users to reveal intimate information about themselves. As such, participants P1 and P3 brought up the possible solution of not connecting the robot to the internet. They believed that the local storing of personal information would hinder third parties to gain access to the robot and would subsequently make them feel more safe about sharing data with the device. However, as P3 pointed out, privacy has been a concern with older technologies that are now widely used, such as personal assistants like Alexa or Siri. He believed that, as time passed and such technologies became more common in households, people would not be as alarmed about sharing their data as they were in the early adoption stages of the device.

Nevertheless, participants could overlook this fear as they knew exactly how their data was being used and knew the researcher personally, which allowed them to make recommendations that would have led them to trust the robot more. P1 seemed to prefer using a more quiet voice, thus creating an intimate space where she could share particular information. P2 and P4 wanted more human-like attributes from the robot,

such as a display of emotions like empathy or talking about itself to the user. The latter attributes demonstrate that the participants would have wished for an overall more organic interaction with the robot, as if they were talking to another person. P4 pointed out that he enjoyed talking to ChatGPT and that he felt like he was conversing with another person at times. While the robot used in the study did not have such advanced capabilities, it appears that having an extended conversational compendium could create a more immersive experience for the user and allow them to talk at length about issues, possibly leading to the disclosing of intimate information in time.

Additionally, the participants wished for more features from the robot, such as taking over certain chores, setting personalized settings based on their habits or improvement of the home automation system they were using. This shows that not only did they want to interact with the robot more in the diary app, but they would have trusted it with personal data about their day as well. It seems that giving users the possibility of personalizing devices could lead to a more trusting and accepting behavior towards it, providing verbal queues and responses are appropriately implemented (Kraus et al., 2022). This is why robotic behaviour that accounts for a person's intimate or defining information could potentially lead to a more emotionally significant relationship with them and have positive effects towards a user's overall perception of social robotics.

Similarly to Lutz & Tamo-Larrieux's findings, this work has underlined the fact that people are particularly interested in a corporation's intention regarding the gathered data (Lutz and Tamó-Larrieux, 2020). However, the researchers also conclude that perceiving positive social benefits from the interaction with a robot might outweigh any privacy concerns they had. While this work cannot support such statements, as participants had no privacy concerns due to personal connection to the researcher, it does point to the possibility that the quality of the interaction with the robot is of primary interest to users.

Lastly, it seems to be more important to design for a better interaction between the robot and the user than for privacy, as the former would lead to earning their trust in more intimate ways than the latter. Designing for privacy mostly appears to allow people to overcome their fears of using a device that collects their personal data, but it is a qualitative interaction that would lead them to want to engage with the device more often and potentially open up about intimate issues.

The second research question that was posed is "To what degree do people employ a social robot in their personal space?". This question can be answered through the wishes or expectations the participants expressed during the interviews, as the placement and capabilities of the robot are subjective to each user and this study, respectively. However, all participants placed the robot somewhere in their line of sight, which resulted in a close proximity to it. They also displayed different ways of talking and relating to the robot, for example by attributing a gender or talking to the device directly. This could mean that users, particularly young people with some technological affinities, would be ready to adopt a robot in their personal space, especially if it displayed advanced capabilities that corresponded to their expectations of it, depending on its affordance.

While one would think about telling the robot about intimate issues in a diary application, they would inadvertently also think of the company behind it and measure their level of trust depending on it. This research leads to the assumption that a well-thought out, qualitative interaction that includes contextual awareness might lead to showing more trust towards a device. It was expected to see intimate information included in the diary entries but, as seen with the third participant who used it as a tracking journal, this is not always the case.

Even though people are aware of the robot's journaling features, they might not necessarily use them as such and instead tailor them to their own needs and habits. Therefore, demonstrating advanced interaction and conversational capabilities might persuade users to take advantage of the diary of the robot and share intimate information. This assumption is also supported by the fact that participants P2 and P4 mentioned finding the act of talking about their day more natural than writing it down. Nevertheless, wanting to share even seemingly superficial information such as alarms, addresses or calendar event also shows a degree of trust towards the robot and underlines the idea that the participants would have trusted the robot enough to converse with it about these matters.

Altering a robot's usage to their own needs is also supported by other research, in which it is concluded that privacy concerns can influence the way a social robot is employed in the future (Lutz and Tamò-Larrieux, 2021). This behavior could be seen particularly in P4, who mentioned in the beginning that he generally uses applications to track his day. The robotic diary application was then used the same way and this intentional behavior was also confirmed during the participants' post-study interview, where he stated that he used the diary more as a tracking medium to keep an overview on that day's activities.

6.5 Limitations

Taking into account the deductions reached above, the limitations of the study also need to be taken into account. One of them, which has been well-known since the beginning of the study is the fact that there is no advanced artificial intelligence employed for the interaction with the robot. All answers of the robot were hard-coded and, as participants pointed out as well, the robot was not reactive to their inputs. It would have been interesting to introduce the participants to an AI that can change its answers depending on the content of its entries and give participants a more "natural-feeling" experience, as formulated by participants.

Another limitation of the AI is the flawed speech recognition API. As P1 expressed, she felt that the mishearing of her sentences led her to stop telling the robot a story in full or to talk as she normally would. This also impeded the possibility of personalising the robot to the user, as there would have been the risk of the robot mishearing details about the user and asking wrong questions, possibly leading to the their frustration. Nevertheless, as stated in chapter 2, personalising the results was an initial intention meant to be respected in the implementation of the diary application. This is why, for

example, the work scenario was chosen for this study, as all participants were employed at the time of the study. Thus, while the question “How was work” seems superficial, it shows a small connection to the participants’ personal life.

Additionally, the scales format of the Godspeed questionnaire also presents a limitation in itself, as scales cannot encompass all of a person’s thoughts on a question. The scales can be misunderstood by the participants and represent another opinion than the one asked about. For example, when looking at P2 s answers of the Godspeed questionnaire, it seems that the participant completed the scales according to their experience of interacting with the robot instead of describing the robot. This could be an explanation to the fact that she gave a higher score on the “unpleasant”/ “pleasant” scale, but a lower one on the “unfriendly”/ “friendly” scale. Subsequently, it can only be assumed that she is firstly rating her interaction with the robot and the latter scales are completed according to her impression of the robot.

CHAPTER 7

Conclusion

In this work, the issue of people's trust in personal social robots was investigated through a study with a diary assistant. Firstly, the robot was evaluated by an interaction expert and modified according to his recommendations. Secondly, four participants of varying backgrounds were asked to create daily journal entries for 4 to 5 days with the robot. Prior to and after the study, the participants were interviewed on their experiences and completed the Godspeed questionnaire. Their answers in all phases were analysed and discussed thematically, as well as compared to each other.

The participants stated that they trust the robot per se, but not the company behind it. It is thus an important first step to have a mechanism in place that does not lead users to think about the organisation behind a robot, but instead let them focus on the interaction at hand. Participants stated that if the robot had no connection to the internet it would make them feel as if their data was more secure. However, current technology is fairly limiting without such a connection, as software updates need to be downloaded and installed for the proper maintenance of devices. Such trust issues towards a big tech company is also a product of certain reputations and assumptions regarding big tech organisations and could be hard to avoid. Nonetheless, when taken out of this context, there seems to be potential value in researching social robots in intimate settings.

As a result of a qualitative analysis, signs that some participants talked to the robot as part of a social interaction became apparent. They would have enjoyed a well-designed interaction with a social robot that reached their expectations in terms of dialog history and context analysis. While breakthroughs in conversational AI are still being made, people seem to have adapted to the idea of carrying out a dialogue with an AI and already have high expectations when talking to a device. As presented in chapter 2 previously, high expectations of robots are nothing new. However, after a period where people could get used to the limitations of a robot, it could be possible that they get a more realistic understanding of what could be expected of robots in the future and help them overcome any concerns regarding privacy.

This work shows that users not only want to dictate a robot their thoughts, but that they would want a full conversation, with different levels of reaction to their inputs. As we have seen at least with some participants, they were willing to tell the device more about their day, underlining the idea that using a social robot to listen to users' thoughts and engaging with them through well-placed questions about their experiences might yield a deeper connection between humans and social robots.

Exterior changes that the participants would have made were a smaller body and different eyes, ranging from blinking to LED-displayed ones. They changed their physical impressions of it mostly based on the eyes, which leads to the assumption that this feature was the primary focus point during their interactions with the device. Seeing the eyes without having an interaction with the robot, in passing, might also affect the level of comfort the participants had with the robot.

Lastly, it seems that participants are not firstly thinking about how robots could help them socially, except if they have a social purpose. While the participants of this study all stated that they do not feel like the robot could help them overcome any emotional issues they had, some mentioned that they could see themselves employing a social robot in the future. Moreover, as robots are primarily seen to have advanced cognitive capabilities but no humanlike understanding, it is no surprise that more people could be educated on the benefits social robots could present in their daily lives. As it stood at the time of the study, the participants were rather focused on practical tasks the robot could help them with, such as home automation, instead of emotional needs.

This study aimed at discovering potential hurdles in the usage of social robots in the situation of a virtual diary application. As personal social robots are not very widespread nowadays, this work can ease the development of such devices in anticipation for future technological advancements. With the help of this study, the gap between the design of social robots' interfaces and the trust level of users is investigated and narrowed down. At the same time, it can represent an incentive to explore ways of increasing robots' possibilities of being trusted with sensitive information and lowering people's weariness against social robots.

Interesting variations on this study that could be looked into in the future would be conducting the study with a robot that is equipped with a more advanced voice assistant. This could allow a more complex creation of scenarios or at least more contextual questions to be asked. The diary application could also be supported by a computer application, which would make the insertion of words and personalising process that participants mentioned missing easier.

Furthermore, P2 exemplified that it would be possible that people could make their own modifications so that the robot behaves the way they want it to, even if it is not necessarily the intended mode of interaction. Discovering such atypical behaviors could further reveal necessary features that users might miss in their interaction with a social robot of this kind. Accounting for a user's expectations but also for their personal needs could lead to the investigation of what different age groups could benefit from

most when using a social robot. This work shows that satisfying advanced expectations regarding conversational abilities could prompt users to engage more with a social robot and possibly uncover further behavioural or cognitive competencies that users might unknowingly expect from them.

As pointed out previously, participants felt that such a robot could be suitable for helping users in situations where they experience feelings of loneliness. Not only could this prompt research to introduce people to social robots that they can form an emotional attachment with, but it also raises the question of using social robots for emotional needs altogether. This lies in accordance with the work of Ananto and Young, who state that employing robots for coping with feelings of loneliness is an area that would benefit from more research (Ananto and Young, 2021).

Interview questions

Pre-study interview questions before seeing robot

- What does the word "robot" mean to you?
- Do you have experience with robots in the past?
- Have you heard of "social robots" before? (show "Paro" if not)
- Where do you see social robots' place in the future (in society)?
- Do you trust persons and organizations related to development of social robots?
- In which way would you customize a social robot that you could use at home?
- Which skill do you think is needed to use a robot and where would you get training?
- Where would you place a robot in your home? How would you place it?
- What role would you consider for a social robot in your home? (ex: assistant, friend, servant, etc)
- How would you feel about robots having emotions?
- Which type of advice (if any) would you take from a robot? (ex: shopping, nutrition, etc)
- Would you take intimate advice from a social robot? (ex: relationships)

Pre-study interview questions after seeing robot

- What are some terms that you would use to describe this robot?
- How does this robot make you feel?
- What capabilities would you expect from this robot?
- What do you think it was designed for?

- Where would you place this robot in your home?
- How often do you keep a journal?
- What information would you tell this robot if it was your journal? -> Tell them that the robot was programmed by the researcher and the data will only be analyzed by the researcher. Show them where they can access their entries Does anything change?

Post-study interview questions

- How was your experience with the QBo robot?
- What are some words you would use the robot now?
- What capabilities do you wish the robot had? Physical and in terms of software?
- Which aspects of the robot (ex: physical aspect, dialog flow, operability) do you think could be improved?
- How do you think the above-mentioned capabilities would have supported you better?
- How do you feel about journaling now?
- (if it makes sense to ask) Could you see yourself in the future using a robot for this purpose for a longer period of time?
- What kind of information did you tell the robot?
- How natural was the interaction with the robot? -> How would you have made it more natural (in order for it to gain your trust)? -> What is your opinion on trust between people and robots? What elements should a robot display?
- How would you describe the interaction in a few words?
- When did you think about talking to the robot? (if it fits to ask): -> Was there an impulse that made you talk to it? (es: when seeing it or setting an alarm) OR was there any point in your day where you thought "I will tell the robot this"?
- Where did you place a robot in your home? Why?
- (if it makes sense to ask) Did you get used to seeing the robot in your home for multiple days?
- Having used a social robot for a while, how do you feel about them now? Do you think that you would use a social robot (not necessarily for journaling) in the future? -> if yes, what would you trust such a robot with?

List of Figures

List of Tables

Acronyms

AI artificial intelligence. 16, 28, 62, 65

API application programming interface. 17, 18, 20, 62

ASOR-5 "Scale for Assessment of Attitudes Towards Social Robots". 12, 23

GA Google Assistant. 16, 17

HCI human-computer interaction. 21

HRI human-robot interaction. 1, 5, 10, 11

MDRAS "Multi-dimensional Robot Attitude Scale". 12, 23

NARS "Negative Attitudes towards Robots Scale". 12, 23

OS operating system. 16, 17

P1 Participant 1. 32–36, 54–58, 60, 62

P2 Participant 2. 37–41, 54–58, 60, 62, 63, 66

P3 participant 3. 41–47, 54–58, 60

P4 participant 4. 47–51, 54–58, 60–62

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